Creativity Theory and Action in Education 1

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Creative Contradictions in Education

Cross Disciplinary Paradoxes and Perspectives

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Creativity Theory and Action in Education

Volume 1

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For Dr. Edward Varra, old friend and fellow traveler in the paradoxes of learning and life.

– Ronald A. Beghetto

To Claire

– Bharath Sriraman

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Introduction: Creative Contradictions in Education

Creativity is a paradoxical construct. One reason it's paradoxical is because numerous contradictions are present in characterizations of creativity. For instance, most people tend to equate creativity with originality and "thinking outside of the box"; however, creativity researchers note that it often requires constraints (Beghetto 2016; Sternberg and Kaufman 2010). Some people view creativity as being associated with more clear-cut and legendary contributions, yet creativity researchers have long recognized more everyday and subjective forms of creativity (Beghetto and Kaufman 2007; Stein 1953). People also tend to associate creativity with artistic endeavors (Runco and Pagnani 2011), yet scientific insights and innovation are some of the clearest examples of creative expression. Although there is general consensus among creativity researchers on the defining criteria of creativity (i.e., some combination of originality and meeting task constraints), differing perspectives persist from some domains (e.g., the arts), which view any definition as being too constrictive.

These paradoxes carry over into educational contexts. Consider, for example, mathematics. A sizeable body of literature suggests that learners do not typically experience mathematics as a creative subject (Burton 2004), yet research mathematicians often describe their field as a highly creative endeavor (Sriraman 2009). Similarly, educators may feel that content standards stifle their students and their own creativity, yet creativity researchers have argued that such standards serve as the basis for classroom creativity (Beghetto et al. 2015). These contradictions place educators in a difficult situation. Consequently, many find themselves feeling caught between the push to promote students' creative thinking skills and the pull to meet external curricular mandates, increased performance monitoring, and various other curricular constraints (Beghetto 2013). The tensions experienced from these contradictions raise several nontrivial questions for educators, including:

- *What role can (and should) creativity play in education?*
- *Why are creative contradictions more likely in some subject areas as opposed to others? Why, for example, do learners often experience mathematics as an*

exercise in rote memorization, yet mathematicians describe their field as highly creative?

- *Is creativity best thought of as an educational goal or a means to attaining some other educational ends?*
- *Is it possible to reconcile the pressure to have students' reproduce existing knowledge with efforts aimed at helping students develop their ability to produce new knowledge (i.e., moving from consuming to creating content)?*
- *Is creativity always a good thing? What are the costs to incorporating creativity in the classroom? Do the benefits outweigh these risks?*
- *What, if any, link is there between the creative imagination and the memorization of factual knowledge?*
- *Does creative teaching and learning require a radically new pedagogical approach?*
- *When might conformity be appropriate and when is divergence needed?*
- *When and how might teachers move from asking known-answer questions to embracing the unexpected?*
- *What are some of the most promising approaches for supporting creativity and are these approaches compatible with academic learning?*

These questions lack clear answers and mirror the types of questions other researchers have raised (e.g., Mayer 1999). Indeed, although the formal field of creativity studies is more than 60 years old, many of the same creative contradictions in education faced by researchers today were faced by the first wave of creativity researchers in the 1950s and 1960s (e.g., Barron 1969). What is different now is that there has been a great proliferation in the field of creativity studies – it is comprised of experts representing multiple disciplines, countries, and methodological approaches.

At present, the field of creativity studies is perhaps best thought of as a transdiscipline. This means that the study of creativity does not belong to any one discipline and that the study of creativity can inform and be informed by multiple disciplines. The transdisciplinary nature of creativity presents an opportunity to examine the paradoxes facing creativity in education with fresh, multidisciplinary eyes. This is the purpose of the proposed volume. More specifically, the purpose of this volume is to bring together leading international and cross-disciplinary experts to weigh in on the creative contradictions in education. Not only will these experts identify and describe key creative contradictions in education, but they will also provide fresh insights into how these paradoxes might be resolved or better addressed.

The chapters in this book are arranged into two sections. The first section focuses on uncovering conceptual issues and barriers. This includes exploring how creativity is defined, the nature of creativity, and the expression of creativity in educational contexts. The second section focuses on practical applications and promising directions. Chapters in this section focus on exploring exemplars of teaching for creativity, the role of play in creativity and learning, teacher's perspectives of creativity, and how creativity can coexist in the constraints of various subject areas. Taken together, this book provides a provocative collection of essays by international experts who tackle difficult questions about creativity in education from a cross-disciplinary perspective. The contributors to this volume will examine and provide fresh insights into the tensions and contradictions that researchers and educators face when attempting to understand and apply creativity in educational contexts. Contributors will draw from existing empirical and theoretical work but push beyond "what currently is" and comment on future possibilities. It is our hope that this book serves as a provocative jumping-off point for researchers and students of creativity interested in developing new insights about creativity in educational settings.

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Part I
Uncovering Conceptual Issues & Barriers

Chapter 1
Big-C Versus Little-c Creativity: Definitions, Implications, and Inherent Educational Contradictions

Dean Keith Simonton

Abstract Two empirical investigations showed that achieved eminence as a creator can sometimes be a curvilinear, inverted-U function of the level of formal education attained by the individual. Typically, the peak falls approximately in the last year of undergraduate education. Because these findings suggest that formal education might not always be conducive to creative development, I examined the possibility that a complex and sometimes conflicting relation might ensue from the very definition of what it means to be creative. From there I introduced two formal definitions, one for personal (little-c) creativity and the other for consensual (Big-C) creativity. The implications of these definitions indeed supported the conclusion that formal education cannot have a simple positive linear association with creativity, and under certain circumstances that association can become negative.

1.1 Introduction

Many years ago I published a secondary-data analysis of the study conducted by Cox (1926) for the second volume of Terman's (1925–1959) classic *Genetic Studies of Genius* (Simonton, 1976). Unlike the other four volumes, which report a longitudinal inquiry into more than 1500 intellectually gifted children, the second volume reports a historiometric investigation of 301 geniuses in Western civilization. The research subjects included both creative geniuses like Michelangelo, Miguel de Cervantes, René Descartes, Isaac Newton, and Ludwig van Beethoven and eminent leaders like Martin Luther, Napoleon Bonaparte, Abraham Lincoln, and Giuseppe Garibaldi. Although Cox's primary goal was to estimate the intellectual and personality characteristics that contributed to achieved eminence, her volume also included the raw data from which it was possible to construct an approximate measure of the

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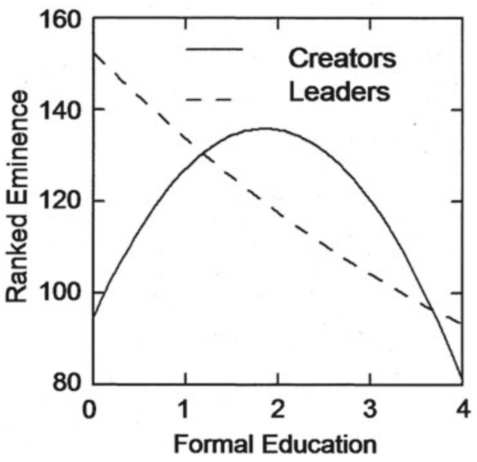

Fig. 1.1 Ranked eminence as a function of level of formal education for 192 creators and 109 leaders making up the 301 geniuses in the Cox (1926) sample (Reproduced from Simonton, 2002). Here *1* = high school diploma, *2* = baccalaureate, *3* = masters, and *4* = doctorate (or their equivalents)

level of formal education attained by each genius. In addition, she provided the ranked eminence scores that the same subjects had received in Cattell's (1903) pioneering historiometric assessment (Whipple, 2004). I then could plot the relation between ranked eminence and formal education (controlling for other biographical variables, such as birth year). Because I conjectured that the eminence-education association might differ for creators and leaders, the plots and the curves of best fit were calculated separately. Figure 1.1 depicts the results (Simonton, 1976).

For those who believe that formal education contributes to eminent achievement, the results must seem surprising. For the leaders, the curve was strictly negative, whereas for the creators the curve was best described as a single-peaked function with the optimum appearing somewhere in the last year or so of undergraduate education! To give an example, consider Galileo Galilei, who was one member of the 301. At his father's urging, Galileo entered the University of Pisa to pursue studies in medicine, but he soon found mathematics more to his liking, and after 4 years finally left the university without a degree. Yet being a college dropout did not prevent him from becoming one of the greatest scientists of all time. According to Murray's (2003) historiometric assessment, Galileo ranks only below Newton among scientists in general and ranks number one among astronomers in particular.

To be sure, that was the "old days" when formal education may not have had the importance it features today. After all, the geniuses who Cox (1926) had studied were born between 1450 and 1850, with a mean year of birth of 1705. Nevertheless, the findings were partly replicated on a more recent, non-overlapping sample consisting of more than 300 eminent creators and leaders of the twentieth century (again controlling for birth year; Simonton, 1984). This sample included such big names as the creators Niels Bohr, Carl Jung, Jean-Paul Sartre, Igmar Bergman, Martha Graham, Maya Angelou, Joan Miró, and Leonard Bernstein and the leaders Indira Gandhi, George Zhukov, Fidel Castro, and Cesar Chavez (complete list in Goertzel, Goertzel, & Goertzel, 1978). The average birth year was now 1902, with a range from 1841 to 1948 (the year this chapter author was born)—about two centuries later than in the earlier sample.

As expected, the outcome departed somewhat from what is shown in Fig. 1.1 (Simonton, 1984). First, for leaders, the education-eminence relation had become positive: Success in modern leadership positions apparently requires more formal education, not less. Most often this education involves law, business, or military school—advanced professional training. Second, for creators, it became necessary to separate the scientists from those active in the arts and humanities. Although the education-eminence relation for the scientists was again a single-peaked function, the peak had been moved to higher levels of training, namely, at least some amount of graduate education. Yet for the remaining 125 illustrious creators—in domains such as philosophy, literature, the visual arts, film, and music—the inverted-U curve shown in Fig. 1.1 was almost exactly replicated. The peak again appeared somewhere in the latter part of undergraduate education. The filmmaker Bergman offers as good an illustration as any. Although he entered Stockholm University College, he got heavily involved in theater and film, actually writing plays as well as an opera, before dropping out to pursue his true passion—the movies.

Want even more recent examples than these? In modern technology alone we can list such notables as Paul Allen (Microsoft), Michael Dell (Dell), Larry Ellison (Oracle), Bill Gates (Microsoft), Steve Jobs (Apple), Larry Page (Google), Evan Williams (Twitter), Hiroshi Yamauchi (Nintendo), and Mark Zuckerberg (Facebook)—college dropouts one and all! Many dropped out even earlier. For instance, high school dropouts include such diverse creators as Walt Disney, Vidal Sassoon, Frank Lloyd Wright, and the Wright Brothers! And this list excludes the extremely numerous number of popular songwriters and musicians who have managed to display tremendous creativity without so much as a high school diploma—like Jerry Garcia of the Grateful Dead.

The foregoing empirical results and concrete illustrations should suffice to suggest that relation between creative achievement and formal education may be at least complex, and sometimes even contradictory. More may not necessarily be better, and might even be worse. To tease out the complexities and contradictions, I would like to start with definition of creativity and then turn to the implications for the question at hand: formal education.

1.2 The Definition of Creativity

Because I have been conducting research on creativity since 1970, I have acquired a perspective that few others enjoy. Although creativity research has grown considerably in the intervening decades, and can boast many striking empirical results, in one critical respect the field has progressed very little: reaching a consensus on the very definition of creativity. Researchers cannot agree on what they are studying! To be sure, the field has no dearth of alternative definitions (see, e.g., Plucker, Beghetto, & Dow, 2004). And some would claim that the field does indeed have a "standard definition," namely, originality and effectiveness (Runco & Jaeger, 2012). Yet the latter definition proves deficient in several respects (Simonton, 2012c, 2013b; cf. Weisberg, 2015b). To appreciate the depth of the problem, consider that anyone wishing to define creativity must address the following five questions:

1. How many criteria are there? As already noted, the standard definition has two, but others require three. For example, Boden (2004) specified that something creative must be novel, valuable, and surprising, which closely parallels the definition used by the US Patent Office, namely, to earn patent protection an invention must be new, useful, and nonobvious (http://www.uspto.gov/inventors/patents.jsp). Sometimes a researcher will propose what seems to have only two criteria and rarely only one, only to prove upon more scrutiny that two criteria have been lumped together (e.g., Amabile, 1996; Bruner, 1962). For instance, "effective surprise" is only a single criterion if there cannot appear ineffective surprises or unsurprising effectiveness, such as safes made out of soap bubbles versus safes made out of stainless steel and reinforced concrete.
2. What are the criteria? Again, researchers exhibit considerable variation, even when they agree on the number. For instance, Kaufman and Sternberg (2006) maintained that "a creative response is novel, good, and relevant" (p. xiii), which seems to split effective or valuable into two separate parts, good and relevant. More recently, Weisberg (2015b) argued for a two-criterion definition that retains novelty but replaces value or usefulness with intentionality.
3. Are the criteria qualitative or quantitative? Surprisingly, few researchers explicitly deal with this question! Most implicitly treat their favorite criteria as dichotomous, zero–one attributes. An idea is original or it isn't, effective or not. Given that the final output of these criteria must be a quantitative variable—for surely ideas or responses vary in creativity—then any qualitative treatment is conceptually insufficient. Once we acknowledge this fact, and accept that all criteria are assessed on a quantitative scale, then we must ask what kind of scaling is most appropriate. The answer must be a scale that has a true zero point that indicates when the idea or response completely lacks novelty, usefulness, or whatever (Simonton, 2012c). The rationale for this essential choice becomes more apparent when we turn to the next question.
4. How are the separate criteria integrated into a single assessment? In other words, how do we combine the judgments based on the chosen criteria into a single evaluation of creativity? There are just two main options: additive and multiplicative (Simonton, 2012c). In the additive integration, ratings on, say, originality and effectiveness would be merely added together. A little thought will reveal that this method will just not work. An idea that scores high on originality but low on effectiveness would still get a decent score on creativity, even if not as high. The various criteria enter into the calculation in a compensatory manner, so that low, even zero scoring on one criterion can be compensated by a high scoring on another. Hence, safes made out of soap bubbles and those made out of steel and concrete would both be deemed creative. In contrast, the multiplicative integration avoids this problem, at least if the criteria have genuine zero points.

An effective idea that has zero originality or zero effectiveness is not creative, period. Zero times any other number, no matter how large, is simply zero. Few creativity researchers are overtly aware of this problem (cf. Grosul & Feist, 2014).

5. Who applies the criteria? This is where creativity researchers often get the most confused. Whatever the criteria may be, or their quantification or integration, who makes the judgment? Is it the individual creator or others outside the creator, others who can even overrule the creator's own assessment? Original to whom? Effective to whom? Although some methods explicitly favor an external evaluation, such as in the Consensual Assessment Technique (Amabile, 1996), others will focus on the creative individual, a focus that seems especially urgent given that it is inevitably within the individual where the initial creativity takes place (cf. Finke, Ward, & Smith, 1992; Guilford, 1967; Mednick, 1962). The outsiders do not create anything when judging a creator's creativity. Note, too, that once we permit outsiders—individuals who were not directly involved in the creative act—when then have to ask: Which outsiders? What qualifications? How many? For how long? Even after the creator's death?

Below I provide a systematic response to the above five questions. It turns out that such a response actually requires two sets of answers, one concerning personal (or "little-c") creativity and the other consensual (or "Big-C") creativity (cf. Kaufman & Beghetto, 2009).

1.2.1 Personal "Little-c" Creativity

I will here argue for a basic three-criterion, quantitative, and multiplicative definition that best fits what I consider to define creativity at the individual level. To obtain an appropriate measure, let us begin by noting that each idea or response to a given situation (e.g., potential solutions in a problem solving episode) can be defined by the following three parameters:

1. The *initial* probability p, or "response strength," where $0 < p \leq 1$. If $p = 0$, then the idea did not initially appear at all, but rather requires an "incubation" period until some unexpected external stimulus or internal associative sequence primes that idea to pop into consciousness (Mandler, 1995; Seifert, Meyer, Davidson, Patalano, & Yaniv, 1995).
2. The *final* utility u, where $0 \leq u \leq 1$, 0 meaning useless and 1 indicating maximally useful (or valuable, appropriate, relevant, effective, good, true, beautiful, etc.). Naturally, in many situations u will be a dichotomous variable assuming values of only 0 or 1. Many so-called insight problems are precisely of this all-or-none nature, such as Maier's (1931) two-strings experiment to be discussed shortly. The final utility is determined and fixed at the time the creative product is completed.
3. The *prior* knowledge value for that utility v, where $0 \leq v \leq 1$. If $v = 0$ then the creator is totally ignorant of the combination's usefulness, whereas if $v = 1$ then

the creator knows its usefulness perfectly, without error. Some value between these extremes represents some "hunch" or diffuse "feeling of knowing state" (cf. Bowers, Regehr, Balthazard, & Parker, 1990).

These three parameters are considered totally *personal*, taking place within an individual creator's mind. Nobody else is involved. Moreover, to a very large extent, the three parameters can vary independently of each other. For instance, v is totally independent of u. One may know for sure that an idea is useless or that it is useful, just as one may be totally ignorant of whether an idea is useful or not. That said, when certain pairs of parameters are considered jointly, then their joint values necessarily constrain the remaining parameter. Most notably, if $u=1$ and $v=1$, then $p=1$, but if $u=0$ and $v=1$, then $p=0$. In words, if the creator already knows the idea will work, then it will have the highest probability, but if the creator already knows the idea will not work, then it will have the lowest probability—at least if the creator is rational! Thus, if $p=1$ even though $u=0$ and $v=1$, then we get the parameters behind the old saying that "The definition of insanity is doing the same thing over and over and expecting different results."

Given the above three parameters, we can then directly define personal, or "little-c" creativity as $c=(1-p)u(1-v)$, where $0 \leq c \leq 1$. If $c=0$, the idea is not creative at all, but if $c=1$, the idea is maximally creative. Here u is the same familiar parameter already defined, but the other two parameters have been inverted by subtracting each from unity. The resulting factors are readily interpreted: $(1-p)$ gauges the personal originality of the idea, while $(1-v)$ gauges the extent to which the idea is deemed surprising or nonobvious by the person.

In brief, I have just defined personal creativity as the multiplicative product of originality, utility, and surprise. The standard definition would omit the third criterion, yielding the truncated equation $c=(1-p)u$ (if a multiplicative integration can still be assumed). This truncation is simply unacceptable. In the first place, the third factor is essential insofar as it informs the individual of how much new knowledge or expertise a particular idea has provided. If $(1-v)=0$, then the creator has learned nothing new, but if $(1-v)=1$, then the learning is maximal—and hence most surprising or nonobvious. Just as critically, without the third factor, it becomes impossible to distinguish between obviously different kinds of *noncreative* ideas. To give an example, let me use the classic two-strings experiment (Maier, 1931). Here the participant was required to tie two strings hanging from the ceiling. Although the strings hung all the way to the floor, they were still too short to tie them together without using some object provided in the laboratory environment. Now consider three scenarios starting with only the first two parameters rather than all three in order to show what's illogically missing.

Scenario 1.1 $p=1$ and $u=0$. Here the idea with the highest probability has the lowest utility. These two parameters describe the participants' most common response when first initiated to the two-strings problem: Just grab one string and walk over to the other string, only to discover that they can't reach it (and some clueless participants then tried the inverse variation in which they then grabbed the other string and walked over to the first one, a response with the same two parameter values). Why would participants do something so stupid? Because they didn't know in advance! That is, $v = 0$. Without the prior knowledge value, their behavior makes no sense whatsoever. Notice that because $(1 - v) = 1$, they were surprised, finding out that the obvious solution didn't work. They thus added something to their knowledge of that situation. Many episodes of so-called "problem finding" are defined by the parameters $p = 1$, $u = 0$, $v = 0$.

Scenario 1.2 $p = 0$ and $u = 1$. The values of the first two parameters have just been reversed, but what a difference! At the beginning, a useful idea has no chance of being evoked. In the two-strings experiment, this describes the solution where the participant takes the pair of pliers, shortens one string, ties the pliers to the string, and then sets it into a pendulum motion so that when the other string is brought over, the pendulum can be caught, the pliers removed, and the task accomplished. But why didn't $p > 0$ if $u = 1$? The answer is again obvious: because $v = 0$, that is, the participants didn't realize that the pliers would solve the problem this way. Indeed, at first, when the experimenter specifically instructed them to use the pliers, they often thought of using them as tongs to extend their reach, which again didn't work, yielding yet another idea with the parameters $p = 1$, $u = 0$, and $v = 0$, as in the first scenario. Lastly, it should be observed that according to the parameters of the pliers-as-pendulum solution, $c = 1$. Indeed, Maier (1940) specifically identified this idea as the *only* creative response to the two-strings problem. Out of four possible solutions, this one alone introduced "an element of surprise and a change in meaning since the tool changes to a weight and the string, which was too short, suddenly becomes too long and must be shortened" (p. 52).

Scenario 1.3 $p = 1$ and $u = 1$. Although these two values seem reasonable, an idea having the highest utility also having the highest initial probability, it remains incomplete because we have to ask how this scenario differs from the previous one, where the utility was also maximal. The answer is clear: It's manifest that $v = 1$, that is, this idea has the highest probability because the person knows in advance that the utility is maximal. This describes the most common response once the participants in the two-strings experiment learned that the first attempted solution didn't work: Bringing the chair over to the middle of the room, grabbing one string and attaching the end to the chair, and then walking over to the other string and bringing it over to tie with the first string. Such a solution can be called routine or reproductive rather than creative or productive because it did not require the participants to use a chair in any unique manner—no different than hanging a purse or coat on the chair. It should come as no surprise, that the parameters $p = u = v = 1$ yield $c = 0$, or zero personal creativity.

Yet there is another version of this third scenario where $v = 0$, in which case we would have an instance of a lucky guess. The two-strings experiment doesn't provide an example, but it's easy to conceive one in gambling. The gambler superstitiously conjures up a "lucky number," goes to the roulette wheel and bets everything on that one number, and wins! Doesn't happen often, and besides $c=0$ nonetheless, yielding another example of a noncreative response.

By now it should be apparent that the third parameter is absolutely necessary for fully defining personal creativity. Without v alternative scenarios just will not make any sense. Furthermore, this third parameter—the creator's prior knowledge of an idea's utility value—will prove crucial for understanding the complexities of the relation between creativity and education.

1.2.2 Consensual "Big-C" Creativity

In personal or "little-c" creativity, it is the creator alone who judges how an idea might score on originality, utility, and surprise. Indeed, with respect to the third criterion, the individual might actually experience surprise, screaming "Aha!" Still, others might disagree with the creator's assessment. They could look at the same idea and say that it is commonplace, useless, or obvious—even all three. Indeed, this reaction is all too common. It happens every time a writer gets a rejection slip from a publisher or a scriptwriter fails to get a green light from the studio after making the pitch. Hence, it is necessary to define another form of creativity according to the following formula $C=(1-P)U(1-V)$, where C, P, U, and V are still quantitative assessments ranging from 0 to 1 (Simonton, 2013b). This is (literally) Big-C rather than little-c creativity. It is based on a consensual evaluation of the three criteria and their joint product.

But herein arises a problem: Who exactly defines this consensus? Unfortunately, there are too many possibilities. At the most minimalist level, the consensus is decided by just one other person. For example, an individual might try to impress a first date by telling some remarkable stories that just make the other's eyes glaze over, bored silly. No consensus! Or the consensus could depend on multiple people in the same situation. It might be a festive celebration in which some clown unsuccessfully tries to become the "life of the party," only to earn disdain. Once more, no consensus! These examples involve informal interpersonal relationships, but the consensus commonly has a more serious side. Very often the consensus depends on coworkers and superiors at the workplace (cf. "professional creativity" in Kaufman & Beghetto, 2009). I once visited Pixar Animation Studios in nearby Emeryville, California, and was absolutely amazed by the creative activity, the various employees playing ideas off each other with a complete freedom that even transcended technical job descriptions. Of course, often individual creativity becomes submerged into collective creativity in which the consensual evaluations are often highly interactive and distributed over time (Paulus & Nijstad, 2003; Sawyer, 2007). Potentially creative ideas get tossed back forth, some getting rejected and others elaborated, until a consensus is finally reached.

In many creative domains, the consensual evaluations will be arrayed into a hierarchy conveying ever higher status (e.g., Carson, Peterson, & Higgins, 2005). At the lowest level, creators will have to survive the judgments of domain-specific "gatekeepers," such as the editors and referees of peer-reviewed journals or the judges involved in juried shows. Should the creator's ideas pass this hurdle, the evaluation continues in the citations that scientists might receive from other scientists or the critical judgments of experts attending the showings. At yet another level are various awards and honors, which themselves can range from the more local to the national to the international. An obvious example of the latter are the Nobel Prizes in the sciences and literature. Finally, if big enough, the creator's ideas will continue to receive posthumous evaluations, as summarized in achieved eminence. The creativity becomes the subject of histories, encyclopedias, and biographical dictionaries.

Naturally, sometimes creative individuals will skip steps in this hierarchy, a possibility especially common among "neglected geniuses." Emily Dickenson published very little poetry in her own lifetime, received no awards or honors, and died in obscurity before she attained the status as one of the greatest American poets. It goes without saying that fame can also operate in the opposite direction, a once widely acclaimed creator slipping into oblivion with each successive posthumous evaluation until he or she ends up with no entry in any biographical dictionary or encyclopedia. Not every Nobel laureate continues to receive acclaim for their work today, and some recipients are even something of an embarrassment. My favorite example is Nils Gustaf Dalén, who got the 1912 Nobel in Physics for his now obsolete inventions concerning the gas-lighting of buoys and lighthouses. And to think that Albert Einstein was by then still waiting for his long overdue Nobel in Physics—which he did not receive until 9 years later!

Note that I have just suggested that consensual creativity confronts a problem less seldom seen in personal creativity. Although creators may change their minds about some of their past ideas—even to the extent of repudiating earlier work—at least it's approximately the same evaluator making those reassessments across the lifespan. Yet once we deal with consensual creativity we are compelled to recognize that the actual evaluators do change across time, and often drastically so. Shakespeare's audiences in Elizabethan and Jacobean London are barely comparable to his audiences today, particularly given that the latter are more likely ignorant regarding the many allusions to contemporary political events in his plays (Simonton, 2004). Hence, some degree of transhistorical instability is to be expected. Fortunately, for the most part, the instability is not absolute so that a substantial number of the truly great Big-C creators do "stand the test of time" (Simonton, 1991, 1998; cf. Runco, Kaufman, Halladay, & Cole, 2010). It's just that the stability of the posthumous consensus is not perfect.

Even if we confine the consensus to a specific point in time, the evaluation of Big-C creativity can reveal various disparities. My favorite example is film (see Simonton, 2011). How do we decide the differential creativity of various movies? The ways are multiple, but three stand out as the most frequent: (a) box office performance, which assigns that task to the cinema consumers; (b) the evaluations of film critics, who are the supposed unbiased experts; and (c) movie awards bestowed by various professional organizations, such as the famed Oscars bestowed by the American Academy for Motion Picture Arts and Sciences. The enigma is that these three methods do not always agree. A blockbuster might be panned by the critics or ignored during the award ceremonies. The film critics often disagree with the professional filmmakers and talents who decide most major movie awards. Moreover, all three consensual evaluations may not necessarily concur with a film's long-term standing, such as the "top-100" assessments of the American Film Institute.

Last but not least, different domains of creative achievement differ in the tightness of any disciplinary consensus (Simonton, 2015a). For example, scientists working in the hard sciences, in comparison to those working in the soft sciences, display a much stronger agreement on who among their colleagues is doing the best work. Thus, physicists show more consensus than sociologists. And the consensus gets even worse for the humanities and the arts. Accordingly, consensual creativity C really should have error bars, the error of assessment being smaller for some domains relative to others (Simonton, 2013b). It necessarily follows from these differences that for high-consensus domains, $c \approx C$, that is, personal creativity will be very close to consensual creativity. But for low-consensus domains, c may be much greater than or much less than C. The former represents creators who overestimate how colleagues will receive their ideas (self-defined neglected geniuses), the latter represents creators who underestimate the reception—indeed, these individuals often have to be discovered and promoted by more established members of the domain.

The bottom line is this: When we speak of Big-C creativity, we must deal with a definition that is far more heterogeneous than little-c creativity. The capital C in the definition given earlier may not only feature quite contrasting font sizes, from 8-point to 72-point, but the font style itself may also change, from Courier and Times New Roman to Arial and Cambria and perhaps even to Ar Berkeley and Mistral! Maybe we really should use the plural: Big-C *creativities*.

1.3 The Implications of the Definitions

Before getting to the implications, I first must affirm my own take on education. Let me admit, firstly, that although I have normally done extremely well academically, I often intensely disliked school, particularly K-12 and graduate school (see Simonton, 2002). As a person with very broad interests and definite aspirations, I too frequently felt that studying, homework, and assignments was interfering with what I really would rather do. Mark Twain may have claimed that "I never have let my schooling interfere with my education" (Harnsberger, 1972, p. 553), but I often found that task too difficult. A good book or an experiment in progress commonly had to yield to problem sets or essay assignments. Even in college, I really hated requirements that were so restrictive that a student seldom had many choices regarding courses. Because I started out as chemistry-premed, I soon discovered that I only had one slot open for an elective course, a slot I fatefully filled with an introductory psychology class that changed my plans altogether. Fortunately, too, I was elected a "college scholar," which allowed me more freedom to design my own course of study. Apropos of the latter opportunity, one of my best-loved Einstein quotes goes "It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mostly in the need of freedom; without this it goes to wreck and ruin without fail. It is a very grave mistake to think that the enjoyment of seeing and searching can be promoted by means of coercion and a sense of duty" (Schlipp, 1951, p. 17).

Of course, in many ways education has gotten even worse since I was in school, especially K-12, with the advent of "No Child Left Behind," the "Common Core," and other interventions to "improve" education. I realize that some others reading this chapter will have a different take on these issues. If so, I think my prejudices should become immediately apparent below. I believe also that readers will understand why from time to time I will lapse into autobiography.

I start with personal creativity before moving to consensual creativity.

1.3.1 Education Versus Personal Creativity

Right from the start I think we can identify a key conflict between traditional educational practices and the requirements for personal creativity. Creative ideas are characterized by originality, utility, and surprise, that is, $c=(1-p)u(1-v)$ so that $p\rightarrow 0$, $u\rightarrow 1$, and $v\rightarrow 0$. Yet education puts pressure on filling up the brain with ideas with the rather different parameter values, namely, $p\rightarrow 1$, $u\rightarrow 1$, and $v\rightarrow 1$. In other words, the student must have the conventionally correct answer ($u=1$) not only quickly available ($p=1$), but also with a strong knowledge base for understanding why that answer is the only correct one ($v=1$; no lucky guesses allowed, so "show work"). This pressure applies whether the testing format is multiple choice, true or false, blank fill-in, short answer, or essay, but the pressure becomes accentuated when the test is timed. The test itself may be one of those standardized tests administered in K-12, the Scholastic Achievement Test, the Graduate Record Exam, or whatever, but it is clear that a student crammed with ideas where $p=u=v=1$ will do better than a student whose ideas fall short of these parameter values. In brief, the emphasis is on routine or reproductive thought, not creative or productive thought.

To be sure, both routine and creative thinking require that $u=1$, so it might seem that they do have a common basis. But we also have to recognize that the utility values most often involve responses to different inputs. Instead of solving problems of one's own making, the emphasis is on solving problems that have been identified as representing the core knowledge that all students should master, such as "What is the capital of Kentucky?" or "Given $x^2=4$, what does x equal?" rather than "What would a light beam look like if you could follow it at the speed of light?" (viz. the question that plagued Einstein since he was 16). One of my teenage hobbies was to conduct experiments of my own design, with a special interest in working out the chemical affinities of various ions. Even though I eventually learned that my research was based on incorrect premises, at the time I deeply resented having to put my lab notes aside to write a dumb book report where the primary goal was to determine whether I actually read the book.

The other two parameters also introduce obstructions. Take the initial probability *p*. The personal creativity of a given idea maximizes as $p \to 0$. Holding the other parameters constant, that means that the most creative ideas have a zero probability of first appearing. As noted earlier, the person must then enter an incubation period before the most creative response attains a nonzero value and enters the mind with a thunderous "Eureka!" That incubation period may last hours, days, months, years. Yet education imposes time limits and deadlines. The essay must be done by the end of the hour, the term paper turned in by the end of the semester. You don't tell your teacher that your essay or paper are not yet finished because you have yet to have a brilliant insight on how to organize the required material with both originality and surprise. So most students learn to retreat to the fallback position, providing a conventional theme and organization. I do not want to remember the occasions in which I received an A+ for a writing assignment that I absolutely despised! Writing a paper that the instructor could have written is a failure, not a success.

Yet of the three parameters, it is the third, *v* or the prior knowledge value, which introduces the biggest problems vis-à-vis education. Remember that this parameter corresponds inversely to the Patent Office stipulation that an idea be "nonobvious." That signifies that the idea is not obvious not just to anybody but rather even to someone who actually has "ordinary skill in the art," that is, to someone who possesses the relevant domain-specific expertise (http://www.uspto.gov/web/offices/pac/mpep/documents/2100_2141_03.htm). Hence, to be personally creative, the idea must not be a straightforward extension of what is already known. If the idea obviously came from the knowledge mastered as a straight-A student, then by definition it is not creative!

So how does one go beyond the known to find something useful that is both original and surprising? As I have extensively argued elsewhere, there exists no magic carpet, skyhook, or miracle that will carry you there (see also Cziko, 1995). Instead, it is necessary to engage extensively in some high-risk process or procedure—variably referred to as "trial and error," "generate and test," "bold conjecture and refutation," or "blind variation and selective retention" (BVSR)—in which multiple possibilities are emitted and evaluated without prior knowledge of their utility values, necessarily leaving a trail of useless ideas (Simonton, 2012a, 2013a). Yet these processes or procedures are far more cumbersome and time-consuming than sticking with the known, particularly whenever algorithms are readily available to answer the question, algorithms that are drilled into the student throughout school and college. For education to prove a success, it matters not one iota that the questions with algorithmic answers are not the questions that one really wanted to ask. I may have wasted many hours conducting my experiments on chemical affinities, time taken away from my formal course requirements. But I learned something far more valuable in the process: How to venture into the unknown.

Some have argued that resorting to the above uncertain methods is unnecessary because the creator can apply a knowledge base external to the domain in which creativity is taking place (Weisberg, 2015a). While this is true, it doesn't solve the problem because it must be asked: Which alternative knowledge base? Any given domain-specific expertise is surrounded by innumerable alternative domains at varying degrees of conceptual distance. Most often it can only be determined retrospectively which extra-domain expertise proves useful, obliging the creator to still engage in trial and error methods (Simonton, 2015b). To illustrate, Galileo's training in the visual arts, and especially the technique of chiaroscuro, enabled him to make astronomical observations regarding the lunar mountains that other astronomers completely overlooked (Simonton, 2012b). Yet at the time no one could have anticipated that artistic expertise would prove useful when looking through a telescope. Given that the prevailing Aristotelian cosmology maintained that all heavenly bodies were perfectly smooth crystalline spheres, the moon could not possibly have mountains anyway. Some of Galileo's contemporaries asserted that they did not have to look through his telescopes because they already knew that his observations had to be wrong!

1.3.2 Education Versus Consensual Creativity

In some respects, education would appear to have a more favorable relation with Big-C rather than little-c creativity. After all, to advance beyond personal creativity, one usually needs sufficient domain-specific training that only formal education can provide. As pointed out at the beginning, this necessity has become especially conspicuous for consensual creativity in the sciences (Simonton, 1984). Galileo might have dropped out of college, but Einstein did not, and even earned a Ph.D., albeit under somewhat precarious circumstances. Indeed, he nearly didn't make it, once proclaiming "I shall not become a Ph.D., which, after all, does not help me much, and the whole comedy has become a bore to me" (Hoffmann, 1972, pp. 40–41). He wasn't even in graduate school but rather was working full time at the Swiss patent office. It is telling that of the major papers that Einstein wrote in his 1905 annus mirabilis—including breakthrough contributions to special relativity, the photoelectric effect, and Brownian motion—Einstein peevishly picked the most trivial and brief (on estimating the size of the atom) to submit for his doctoral dissertation. When one of the professors complained that it was too short (for it's only 20 pages long in print), Einstein added one sentence and resubmitted it to get his degree. He obviously had a very low opinion of the whole educational process.

Nonetheless, the education-eminence relation becomes more complex for other domains, especially low-consensus domains such as the arts and humanities. As previously observed, the curvilinear inverted-U relation seen for the creators in Fig. 1.1 was basically replicated in a twentieth-century sample of eminent philosophers, creative writers, visual artists, filmmakers, and composers (Simonton, 1984). Hence, we might speculate that education makes a positive contribution to creative development up to the end of undergraduate education, but begins to exert a detrimental effect should the person progress to graduate or professional school. It is likely that the training then becomes too specialized and demanding to support the continued acquisition of creative potential. So even today, we see college dropouts making Big-C contributions in the arts and humanities. Among the most famous contemporary cases is the great filmmaker Steven Spielberg, who was born in 1946.

Yet it must be emphasized that such dropouts are not dropping out of education per se, but rather they are dropping out of *formal* education—which is what was assessed along the horizontal axis in Fig. 1.1. Formal education is then replaced with self-education and on-the-job training in which creators can acquire the breadth and depth of knowledge requisite for pursuing a high-impact career in their chosen domains of creative achievement. Spielberg didn't just drop out of college to bum around Los Angeles. Already as an undergraduate he acquired an unpaid internship at Universal Studios and by the time he left college he had remarkably signed a 7-year directing contract (the youngest ever to do so). Spielberg's early work at a major Hollywood studio was certainly worth far more than a bachelor's degree in English—albeit he did return to finish his degree after already becoming world famous!

Lastly, it should be noted that exceptional creativity is strongly associated with openness to experience (McCrae & Greenberg, 2014). Big-C creators have broad interests and diverse hobbies. This openness is not just recreational. I mentioned in the previous section how Galileo's involvement in the visual arts facilitated his telescopic discoveries. Such stimulating interplay between the openness and scientific creativity continues among Big-C scientists today (Root-Bernstein et al., 2008; Root-Bernstein, Bernstein, & Garnier, 1995). A particularly striking case is the Nobel laureate Murray Gell-Mann whose interests span historical linguistics, archaeology, birdwatching, antiques, and ranching, among other things. Like most Big-C creators, Gell-Mann is an omnivorous reader, and his extra-scientific reading will sometimes leave a trace in his science. He won the Nobel for his work on elementary particles, a domain in which he introduced two key concepts—the quark and the Eightfold Way. The former was taken from James Joyce's *Finnegan's Wake*, the latter inspired by the Eightfold Path of Buddhism.

Needless to say, such broad interests are seldom supported by formal education, and too often the demands of advanced training just get in the way. How many of us have given up some favorite interest or hobby to narrow our focus on getting that darn doctoral dissertation done?

1.4 Conclusion

This chapter began by reporting two empirical studies indicating that achieved eminence as a Big-C creator is often a curvilinear, inverted function of the level of formal education attained (see Fig. 1.1). I also provided concrete illustrations of creative geniuses for whom education seemed to have less than a positive effect. With that as background, I then entered into a detailed discussion regarding the very definition of creativity, including both personal and consensual forms of the phenomenon. The resulting definitions then had implications for understanding the role of education in both little-c and Big-C creativity. Ample reason was given for why formal education can often have ambivalent and even negative consequences for creative development and achievement. My treatment is no doubt incomplete. For instance, I made no effort to discuss a closely related issue, namely, the relation between scholastic performance and creativity. Nevertheless, this chapter should still make anyone think twice before judging a person's creativity by the number of degrees listed after the surname. The list might not even include a bachelor's degree or high school diploma!

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Chapter 2
The Nature of Creativity: Mayflies, Octopi, and the Best Bad Idea We Have

Jeffrey K. Smith and Lisa F. Smith

Abstract What is creativity? This chapter explores various definitions of creativity that have been proposed since the inception of creativity research, along with models and measures of the creative process. Classical approaches to creativity focus on what are known as two-criterion and three-criterion models. All models include some variation of novelty and usefulness as two of the three criteria, with three-criterion models employing surprisingness or quality as a third criterion. We propose a definition of creativity that focuses on the process through which people arrive at good ideas, and argue for a "1.5" criterion model. Specifically, we argue that creativity involves novelty (that becomes surprisingness toward the high end of the spectrum) as one criterion. And we argue that the .5 of a criterion relates to the notion that an idea has to have the *potential* to be useful in order for it to be creative. That is, an idea does not have to ultimately prove to be fruitful in order for the process that generated it to be considered to be creativity; it only needs to have a possibility of being useful. This allows for great ideas that did not come to useful fruition (e.g., Leonardo's "helicopter") still to be considered creative, while relegating fundamentally silly or inappropriate ideas to the non-creative bin. We show how this definition and approach to the criterion problem solves a number of thorny issues in creativity scholarship.

2.1 Introduction

Mendez: There are only bad options. It's about finding the best one.
Turner: You don't have a better bad idea than this?
O'Donnell: This is the best bad idea we have, sir. By far.

The lines above are taken from the movie *Argo* (2012) as the principals debate how to rescue a number of American diplomats hiding in the Canadian embassy in Iran. The decision is taken to pretend to be a film crew in Tehran, an idea which

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seems absurd on the face of it, and yet simultaneously appears to be the best of a poor set of options. It is, "the best bad idea we have."

Would one consider it to be creative? Well, it was novel, and it did work. So by most standard definitions of creative, it would fit the bill (Runco & Jaeger, 2012). But what if it had not worked? What if it had failed, or more intriguigingly, what if it had been rejected in favor of a different alternative? Would it have still been creative? The idea itself is identical in all the possibilities. If, in fact, the multiverse, with an infinite number of universes exists, then each of these possibilities has been realized. So, does this identical idea get marked as creative in some realities and not in others?

If we look at creativity from the variety of definitions provided for the concept, we can get one perspective on the nature of creativity (e.g., Kaufman & Sternberg, 2010). If we look at theories of creativity (e.g., Eysenck, 1995; Sternberg, 1985), we can get a second perspective, and how it is measured would provide a third perspective (e.g., Plucker & Makel, 2010).

Why is it important to consider these various perspectives on creativity, or to consider a definition of creativity at all? A number of reasons come to mind. First, in order to understand something, we need to know what that thing is – not just its characteristics, but what kind of a thing we are talking about: animal, mineral, or vegetable? Second, in order to develop something like creativity in individuals, we need to know what we are working on. Third, in order to measure it effectively, we simply have to know what *it* is. The essence of the issue here is, "What is the essence of the issue?" Therefore, we need a definition, and if there is an orthodoxy battle over that definition, that means that work still needs to be done. Thus, we are interested in looking at what definitions of creativity currently exist and how they might possibly be improved upon. This chapter critiques the definitions and models that are currently available for creativity, and provides an alternative definition along with an examination of how it would be effective and useful. We begin by looking at definitions of creativity that have been offered in the literature, then at models and theories of creativity, and finally at measures of creativity. Through this examination, we come to a somewhat new approach to the problem and offer (yet another) definition of creativity, one that we believe has some appealing characteristics.

2.2 Defining Creativity

What is creativity? A multitude of definitions have been offered over the years, and the discussion/debate over a definition continues unabated. But we might start this examination with a more fundamental question: what *is* creativity? That is, regardless of nuance, or what should be included or left out of a definition of creativity, what are we talking about? If you were to receive some creativity, what would you have? Is it a mental ability, a disposition, the outcome of a process, a characteristic of a product? Is creativity similar to intelligence or self-efficacy, or is it more like justice, treason, or perhaps beauty? Is the Mona Lisa creative? Was Leonardo creative, or was it the process through which he generated the Mona Lisa, or the nature of the times and his station that caused him to paint it? Or is the Mona Lisa simply outstandingly beautiful and intriguing, and not actually creative at all? And while we have Leonardo in mind, is the Mona Lisa more or less creative than Leonardo's plan for a helicopter (the aerial screw)?

Weisberg (2015) argued that the standard definition for a product to be creative is that it must be novel and of value. Kaufman and Sternberg (2010) posited three criteria: novelty, quality, and appropriateness. After having studied a raft of definitions of creativity drawn from the research literature, Plucker, Beghetto, and Dow (2004) provided a slightly more elaborate definition:

> Creativity is the interaction among *aptitude, process, and environment* by which an individual or group produces a *perceptible product* that is both *novel and useful* as defined within a *social context*. (p. 90)

Based on ideas drawn from Bruner (1962), Simonton (2012) argued for a three-criterion definition of creative ideas. He proposed that, "An idea then displays creativity to the extent that it is new, useful, and surprising" (p. 98). Many other authors have weighed in on this topic, but the nut of the issue is whether one goes with two criteria, as perhaps originally proposed by Barron (1955), or three criteria, as promoted by Simonton (2012) and others.

Putting aside whether three criteria are better than two for a moment (along with what those two or three criteria would be), it seems to be the case in each of these definitions that creativity is something that is characteristic of an idea or product, or in the case of the Plucker et al. (2004) definition, an "interaction" (p. 90) that results in a product. Thus, creativity from this perspective is something that we should be able to observe in, or induce from, an object that is tangible, either physically, or intellectually. It is something that a product or an idea *has* – creativity. But if creativity is a characteristic of a product, what about the mental process(es) that resulted in the product? Were they creative? Were they *creativity*? If creativity is inherently an attribute of a product, what is the process that produced it? Creative thinking? Creative behavior? When we think of a concept like intelligence, we think of it as being a characteristic of individuals. When we think of beauty, we think of a characteristic of objects (broadly speaking). Before we can properly define something, we need a solid notion of the type of thing that we are talking about. Definitions of creativity often fail to explicitly state the nature of the beast. We defer offering our perspective on this question until we have explored models and measures of creativity.

2.3 Models of Creativity

In a book on creativity such as this one, presentation of theories/models/conceptualizations will not go wanting, so in this chapter, we will only examine that work which helps us make the case for our approach. This is not intended to denigrate other excellent work in the field, but rather to say that our space is limited. Please do look at the other, excellent work contained in this volume to sample the breadth and depth of this field. For now, we look at three prominent theoretical approaches to creativity, taking from each of them what we can to further the pursuit of a definition of creativity.

The 4/6/8 P Model of Creativity The 4P model of creativity was developed by Rhodes (1961) and presented in a short, but highly interesting article in *Phi Delta Kappan*. One of Rhodes' main concerns was to develop a definition of creativity. In considering a definition, Rhodes examined a number of aspects of creativity that he was able to label with four words beginning with the letter P. The Ps referred to are thought of as aspects or facets of creativity (Kozbelt, Beghetto, & Runco, 2010). They are: person, product, process, and press. Creative persons make creative products using a creative process in a creativity stimulating environment (press—perhaps the one real reach for a P). This 4P model has been examined extensively over the ensuing decades, expanded and elaborated upon. There are now competing 6P models, including the addition of persuasion (Simonton, 1990), and potential (Runco, 2003, 2004), as well as an approach breaking person into three components: personal motivation, personal properties, and personal feelings (Cropley & Cropley, 2009). The facets of creativity in the 4/6P models work together to produce creativity. Thus, the idea of creativity becomes more complex. If we add all the facets proposed together, we would have an eight-faceted model of creativity, an 8P model, or perhaps "the creativity octopi." But unlike the rhythmic coordination of the tentacles of an octopus, six concepts in a theory gets a bit complicated. Thinking about the possibility of eight borders on the unruly. As the fourteenth century scholar William Ockham said, "Nature does not multiply entities unnecessarily."

Although the 4/6P models of creativity are excellent at helping us think about the *possibilities* that creativity engenders, they are not as helpful in generating a single, concise definition of the term. Quite the contrary, they help us understand the inherent difficulties in doing so, as they present a multitude of options for thinking about what creativity essentially is.

2.3.1 Big-C, Little-c, Mini–c, and Everyday Creativity

A second popular approach to conceptualizing creativity has to do with the magnitude of the stage on which it appears. Big-c creativity is the creative work that we all know about and that has changed the world in some fashion such as Edison, Picasso, or Plath. The origins of the term Big-C are a bit obscure (Merrotsy, 2013). Little-c creativity is similar to "everyday creativity" and has to do with the creative ideas that do not change the world, but that might lead to a resolution of a traffic problem in a town, or combine ingredients into a recipe that is novel and tasty (Richards, 2007, 2010; Silvia, et al., 2014). These sometimes might be thought of as the kind of thing one would see in a "life hack" website. Everyday creativity has been extensively studied by Richards and her colleagues, and it is perhaps somewhat unfair to combine it with the big to mini scheme, but our concern here is to carefully consider the consequences of differing definitions of creativity, and for those purposes, little-c and everyday creativity are quite similar. Then there is mini-c, which has to do with creativity that is novel and useful to us as individuals, but which may not be seen as such by others (Beghetto & Kaufman, 2007). It helps us navigate our lives and provides moments of satisfaction with small creative triumphs. It also is seen by Beghetto and Kaufman as the seed from which more mature creativity grows.

Looking at creativity in this fashion helps bring into focus the role of both the usefulness criterion of creativity and the distinction (or lack of same) between novelty and surprisingness. In everyday and little/mini-c, the novelty tends to be defined at the level of the individual: is this idea new to the person who has generated it, as opposed to novel in a grander sense. But, if it is novel to the individual, is it also surprising? Does creativity require not only coming up with something new, but also something that is (at least a bit) surprising to the individual? Does it require a novelty that is in some sense unexpected?

2.3.2 *Blind Variation and Selective Retention*

Blind variation and selective retention (BVSR) was first proposed as an approach to creativity by the eminent social psychologist, Donald Campbell (1960). Martindale (1990) and then Simonton (2001, 2011) revived the model after decades of neglect and engendered a sprited discussion of the model with other creativity researchers and scholars. At the heart of the BVSR approach is the notion that creativity occurs through the blind generation of alternative solutions to a problem, each being somewhat independent of the previous ones, and then each alternative is considered and either rejected as not being useful, or accepted as being an appropriate solution. Campbell (1960) described the process as follows:

> The process *as a whole* of course provides "foresight" for the overt level of behavior, once the process has blindly stumbled into a thought trial that "fits" the selection criterion, accompanied by the "something clicked," "Eureka," or "aha-erlebnis" that usually marks the successful termination of the process. (p. 384)

This is an incredibly rich sentence for thinking about creativity. First, it is bold in that it actually says, "this is how creativity works," – not what it is similar to, not its characteristics or aspects, and not the various venues and means where one might encounter creativity. Campell argued that this is the process through which creativity is generated. And although he did not do so explicitly, he answered one of the fundamental questions of creativity: what is it? For Campbell, it is a *process*. It is a particular process to be sure, and one that is not widely accepted as an accurate explication of the process. For our purposes here, what is important is that it places a stake in the definitional ground. And it is a stake that warms our hearts. To us, if we are defining creativity, we are defining a process, one that occurs within the mind of the individual; hence, a psychological process. Now, it is possible to disagree with Campbell on this point, but there is much to like in this position. It gives us something to hold on to. Whatever one might think about people being creative, or engaging in creative behavior, or a product or idea being creative, or an environment encouraging creativity, the idea that creativity itself, taken down to its essence, is a psychological process, just makes sense.

There is a second aspect to this sentence that we find appealing. Campbell (1960, p. 384) told us that once a "trial thought" fits with the appropriate selection criteria, it induces an "aha-erlebnis" moment (we had to look that one up, too) that *ends* the process of creativity. That is a loaded notion from several perspectives. First, it tells us that once an idea fits the criteria, creativity is over. The process ends. Thus, creativity is a mayfly, here for a day and then replaced by the thing it created. It is what Thomas Jefferson called, "…the fugitive fermentation of an individual brain…." (Thomas Jefferson letter to Isaac McPherson, cited in Lipscomb & Bergh, 1905, p. 42). The rest is details. Well, the rest is realizing the creative idea, which perhaps may require a bit more creativity here and there, but the working out process, if examined, is usually anything but creative. Bringing Jefferson's fugitive fermentation to fruition requires the "99 % perspiration" that Thomas Edison warned us about. The second point worth noting here is that Campbell merely required the "trial thought" to align with the selection criteria. Campbell was not looking for Big-C or little-c; he was not looking for the idea ultimately to be useful, or appropriate, etc. He was happy with it being assessed, in the mind of the thinker, that this is an idea that "fits." But what if in the long run, in the execution of the idea, it does not work? What if this idea looked attractive, and had some good characteristics, but in the end was not productive (Leonardo's helicopter)? Do we go back and label that whole process as something other than creativity? Of course not. But that means that we have to give the notion of usefulness or utility a bit of a closer look, which we do in a subsequent section.

At the end of the day, we think the BVSR model has aspects that are appealing, but it relies too much on the concept of possibilities popping up from some mysterious possibility generator rather than a more purposeful blending of the constraints of the situation with deliberately chosen possibilities that seem unrelated to the problem, or only tangentially related, and then exploring what might be good about such possibilities, and then refining one's search for solutions. Having said that, we also think the BVSR is an excellent jumping off point for seriously thinking about the process that creativity is.

2.4 Measures of Creativity

We now turn to measures of creativity. Descartes is reported to have said, "Whatever exists at all, exists in some amount." Sadly, Descartes did not say that; E. L. Thorndike did (Thorndike, 1918, p. 16) and he was not quoting Descartes. But, Thorndike was a fine scholar and good enough for our purposes here. When we want to understand something, considering how we measure it is not a bad place to look for answers. There are multiple measures of creativity available to examine, and they provide a number of distinct conceptualizations of the concept. We have measures of creative processes, creative people, creative products, and creative environments.

Perhaps the best known measures of creativity are those that tap into the notion of divergent thinking. These include the Torrance Test of Creative Thinking (Torrance, 1962), the Structure of Intellect test (Guilford, 1967) (the part of the SOI that measures creativity), and measures developed by Getzels and Jackson (1962). The underlying idea of these measures is to have the testee generate responses for various prompts, and to measure the fluency, originality, and flexibility of those responses (Plucker & Makel, 2010). What is being measured is the ability of the testee to generate a *lot* of ideas, ideas *that were not selected often by others*, and ideas that represent a *broad range of categories*. Thus, the divergent thinking measure looks at the efficacy of the person in generating ideas. It is a measure of the process of idea generation. The quality of the ideas is not measured (except for uniqueness), nor are the ideas themselves measured. That is, one does not look at idea X to see how often it was mentioned as an indicator of how creative X was. One could do that, but that is not the goal of divergent thinking measures.

There are also measures of creative persons – their personalities, dispositions, attitudes, etc. (Feist, 1998; Torrance & Khatena, 1970). Some are directly targeted toward the issue of creativity, and others are used as independent measures of personality to see what kinds of personalities creative persons have. Perhaps the most interesting for our purposes comes from Beghetto (2006). In developing a measure of student creative self-efficacy, Beghetto (p. 450) constructed a three-item scale:

I am good at coming up with new ideas.
I have a lot of good ideas.
I have a good imagination.

We think that Beghetto has fundamentally hit the nail on the head with regard to what creativity is. We later blend together several of the ideas represented in this scale into our definition of creativity.

2.5 How Many Criteria Are We Really Talking About?

This is a bit of a difficult section to write because it contradicts the thoughts of scholars who have worked hard on this issue and made good arguments for their respective positions. If we examine the arguments for various definitions of creativity, basically four ideas are brought to the fore: novelty, quality, appropriateness, and surprisingness. But perhaps these might be better conceptualized as basically being two criteria, not four.

To begin, novelty and surprisingness are closely related concepts. One can argue for differences for certain; an idea can be new, but mundane. Perhaps there is a nut somewhere in the world that has not yet been turned into a butter (peanut butter, almond butter, cashew butter, etc.). Making such a product would be novel, but not particularly creative. Turning a nut into rocket fuel, however, would be surprising. But we can turn this argument around: can something be surprising without essentially being novel? Can you be surprised by something that is common? Well, examples might exist, but they might be difficult to come by. Our point is that novelty and surprisingness seem to be fairly similar ideas. One might even consider surprisingness to be an extreme form of novelty. If we put novelty and surprisingness into the same basket, it would not be all that odd a basket.

There is a name for things that are responses to situations that are novel/surprising. We call them ideas. The word idea connotes novelty and/or surprisingness. If one says, "Here's an idea," one is basically saying, "I've come up with something new and different with respect to this situation." If someone simply applies a well-learned, tried and true algorithm to solve a problem, we don't usually refer to that as an idea. We refer to it as working out the problem. Using Simonton's (in press) notion that a definition of creativity has to help us rule out what is not creative in addition to ruling in what is creative, novelty/surprisingness seems to be *sine qua non*. If something is not novel, it is hard to see how it can be categorized as creative.

The other set of criteria for creativity has to do with usefulness/appropriateness/quality. This seems to us to be fairly similar in form to the novelty/surprisingness issue. If something is useful, can it be not appropriate? If an idea is of high quality, can it also be not appropriate to the situation, not useful? Again, perhaps one could generate examples of this situation, but they would be strained. If the terms useful, appropriate, valuable, quality, etc. were thrown into some sort of cosmic factor analysis along with new, novel, surprising, etc., our guess is that any rotation would generate a two-factor solution. And we are loathe to complicate the matter more. As the multivariate statistician Darrell Bock once noted, "I have never seen a four-way interaction that did not ultimately turn out to be a keypunching error." (Bock, 1973, personal communication.) With regard to the useful/appropriate/value criterion, we might argue that Beghetto (2006) found a good general term for what we want ideas to be: "good." "Good" pretty much covers it. But to push our yearning for parsimony to the limit, do we even need "good?" We believe that novelty/surprisingness is essential, but what about a really novel, surprising idea that is not good? Would/should we consider that creative?

2.6 Should Creativity Only Have One Criterion?

We have examined arguments for a two-criterion model of creativity (novelty and usefulness) and a three-criterion model of creativity (novelty, usefulness, and surprisingness). For purposes of analysis, we have boiled them down into two broad categories of criteria (the "novelty" basket and the "usefulness" basket). We now turn to the notion that perhaps a one-criterion model might be the best, by providing a critique of the two-criterion definition. We can construct this critique by again returning to the "Simonton test" (Simonton, in press): how well do these definitions allow us to see ideas that are clearly *not* creative?

We start with Leonardo's helicopter. We all know this image, and are all amazed at the stunning creativity it displayed. But Leonardo never tried to build it, and from a modern perspective, it looks like it never would have flown. So does that mean we have to go back and label it *not creative*? Do we really want a definition of creativity that does not include Leonardo's plan for a helicopter? In addition to simply seeming to be unfair, it calls into question, in our opinion, the reality-base of the usefulness criterion. Although one could argue that there are distinct similarities between Leonardo's work and modern helicopter development, most aviation engineers would be skeptical. But, if we want to include Leonardo's helicopter, do we have to jettison the usefulness criterion? In a similar vein, we know that the Copernican model of the Universe is not really true, but it is hard to argue that it was not creative. Related to this, aspects of the theory of relativity took decades to establish, but the stunning creativity of the theory was recognized right away. So did it become more creative as tests of it confirmed its essential rightness? And should relativity be superceded, will it become non-creative?

This analysis is, of course, unfair, but it serves a point. What do we do with an idea that is bold, novel, suprising, but does not work? And what if it not working is not a function of the quality of the idea, but some aspect of its realization that was fundamentally unrelated to the idea quality? For example, there might be a highly creative battle plan that fails because freakish weather does not permit its execution. What about a brilliant idea for a book whose author dies before it is completed? What about Emily Dickinson? Was her work creative from when pen was put to paper or only when it was discovered, published, and ultimately acclaimed? If it falls out of fashion, will it become less creative? These possibilities are vexing, and they have to do with the definition of the term and what types of things we want to count and not count as creative. We do not want to define ourselves into a box where nobody else wants to play. That is, we do not want a definition of creativity that makes creativity theorists happy, but bears no relationship to the notion of what creativity is in the broader world. We occasionally have to make reality checks on what we are talking about.

So, what if the "usefulness" criterion is taken out of the two-criterion definitions? What would creativity look like if there were only one criterion: novelty? To be honest, that is where we started out when writing this chapter. But as so often occurs when thoughts make it to paper, the concept did not look as good in black and white as it did in gray matter. Let us consider the possibility of a one-criterion definition. It has the distinct advantage of simplicity. All one has to do is look to see if the idea/product had not been thought of before (or with mini-c, not in the context of the individual coming up with the idea). And it sits well with some common sense notions of creativity. Consider two ideas or products. One is very novel and marginally useful and the other is very useful but only marginally novel. Which one would generally be considered to be creative? It seems simple to make the argument for the highly novel, not so useful idea. The other idea might be considered to be really good, but generally, we would not think of it as particularly creative.

Or take a different tack on this. Imagine an elementary school classroom. The topic in the lesson plan is "creativity." What is the teacher likely to be doing? Is she more likely to be working with children on generating novel ideas, or more likely to be working with them on assessing the quality of their ideas? Or just consider general usage of the term. The essence of creativity is novelty, that which is unusual or surprising (see Baas, Koch, Nijstad, & De Dreu, 2015, for an exploration of the beliefs of laypeople with regard to creativity).

The problem we are left with is that we recognize that without the usefulness criterion, anything, no matter how silly, could be considered creative. Consider a mom and dad trying to figure out how to get their kids to come in from playing outside in time for supper. The dad says, "We could have a giant blue cow fly over the city and call them home fifteen minutes before dinner." That would be a novel (some might say surprising) approach to the problem, but it is so ludicrous that we do not really want to call it creative, except in derision. But, if we insist on usefulness as a criterion, then many things that clearly seem to be deserved to be called creative (think Leonardo's helicopter) will not be. What do we call an idea is germane to the setting, and holds potential to be useful, but then does not live up to that potential? If we think back on Campbell's (1960) notion of a "trial thought" being positively assessed by the individual engaged in the process as the end of the creative cycle, then the ultimate usefulness of an idea may be a bridge too far for defining what we think creativity to be. This dilemma leads us to our proposition for a definition of creativity and the optimal number of criteria.

2.7 A Definition of Creativity

This analysis leads us to the definition of creativity that we wish to propose. We came up with this notion independently of looking at Beghetto's self-efficacy scale (Beghetto, 2006), but we acknowledge the massive similarity. We believe that an appropriate definition of creativity is as follows:

Creativity is the process of coming up with a good idea.

That's it. That is where we are staking our claim. It is deceptively simple, but we think it covers the necessary bases and does not add any superfluous ones. In this definition, we are making three arguments. First, creativity is a process, a mental process. Creativity is *not* a product nor a characteristic of a product; it is *not* an inherent aspect of an individual; it is *not* an environment, nor a potential. It is a process. It is what happens when an individual in some fashion generates a response to a situation that has some degree of novelty and the potential to be useful (more on that in the next section).

This definition allows for creativity to exist in large and small amounts, to be deemed relevant to a person or a society, and to not be limited to a particular approach or location in the brain. It is readily comprehendible in common parlance, and provides a clear basis for research. It allows for a highly creative person to be engaged in an activity that is *not* creative, and a less creative individual to be engaged in a creative process. It allows for products to be the outcome of creativity, and not creativity itself. Creativity is a mental process and thus not directly observable. What we observe is the outcome of this process and we look for certain characteristics in that outcome in order for it to be deemed more or less creative.

2.8 The "1.5 Criterion" Approach to Creativity

With a simple and clear definition of creativity, we return to the "criterion problem." We see creativity as the process through which people come up with ideas and give them a kind of reality check, á la Campbell (1960), to see if the ideas look like they might be useful for the task at hand. This process can exist at a mini-c level, little-c level, or at a Big-C level, although we envision Big-C as more of a series or combination of ideas (maybe spurred by one large idea). In everyday language, when someone comes up with an idea and puts it to the "usefulness" test, one is essentially asking, "Is this idea a *good* idea?" "Good" covers a multitude of possibilities. An idea is good if it is potentially useful, appropriate to the task, of value, beautiful or dramatic (when beauty or drama is the goal), or sensitive when one is in need of sensitivity (perhaps in talking to a bereaved friend). Good has depth and breadth.

With regard to the criterion problem, the definition we proffer clearly hangs on two words: good idea. *Idea* covers the notion of novelty/surprisingness. Ideas are things that are novel. If one needs a title for a book, *Gone with the Wind* does not really cut it in terms of being an idea. Coming up with an idea essentially means coming up with something new. As mentioned above, without novelty, creativity does not exist. One might be solving problems, painting beautiful pictures, or writing a great novel, but without some notion of newness, it is hard to see how it would be creative. Not all writing is creative, nor is all art. For example, no one has ever written this particular sentence before (we googled it), but even though it is original, it is not creative. It is pedestrian. So the first criterion, the “1” in our “1.5 criterion” model is novelty/surprisingness, which we conceptualize as basically a continuum.

That leaves the “.5,” which is what we are considering the “good” part of our definition. We are arguing that an idea ultimately does not have to be successful for it to be creative. We argue instead that an idea needs to have the potential to be successful for it to be creative. An idea that is novel and *might be* useful/valuable is a creative idea. And the process that generates an idea that is novel and good is creativity. This definition allows for Leonardo’s prescient but earth-bound aerial screw to be right at the heart of creativity, and “dad’s” idea for the flying blue cow for children retrieval at dinner-time not to be creative. Thus, for us, good means something that *could* work. It has a chance of working. It might work, but it might not. It’s stochastic. We won’t know until we explore it in more detail, but at its inception, it holds enough potential to warrant that exploration. Such an idea is a good idea – one that could work. We don’t want to give it a whole “1.0” so we are considering it a “.5” criterion. We don’t actually know what the likelihood of any idea ultimately being successful in any given situation will be, so the “.5” criterion gives it an intuitively appealing 50/50 connotation.

Thus, a creative idea is one that is clearly novel, perhaps all the way to “surprising” and which has a chance of being successful if pursued. Novelty is an absolute criterion in that if an idea is not in the least bit novel, it is also not in the least bit creative. Good means that the idea has a chance of being successful. If the chances are zero (flying blue cow), then the idea is not creative. For an idea with a given level of novelty, the greater the chances for success (usefulness, beauty, appropriateness, etc.), the more creative the idea is. If the idea ultimately is not successfully, but might have been, we think that most people, and most researchers, would want to categorize that idea as creative, and the process that generated it as creativity.

2.9 What Does This Definition and the 1.5 Criterion Model Mean?

Definitions of concepts in science have to serve the scientific endeavor, and models have to be useful. If we define creativity as the process of coming up with good ideas, and adopt a criterion model of “novel and potentially useful,” what have we gained? A lot, we think. First, we think it makes a simple and perhaps even obvious statement that creativity, in its essence, is a mental process. People can either be engaged in it to a greater degree or a lesser degree, or perhaps not at all. Some people can be better at it than others. Some environments might promote it better than others. And the ideas and products that are the result of it can be studied as reflections of an underlying mental process. A caveat on our language is in order. We think that creativity is probably not a single set of activities. That is, different people may engage in creativity on the same problem in different fashions. Or, the same person may engage in creativity in different fashions in different situations.

Creativity is not a location in the brain as much as it is a confluence of mental activities (see, e. g., Kaufman, Kornilov, Bristol, Tan, & Grigorenko, 2010). It is a process that people choose to engage in, in order to solve problems, generate solutions to situations, communicate their ideas, etc.

This definition and model for criteria allows us to say, "That's a creative idea! Might not work, but it might!" or "It's a crazy idea, but it just might work!" It allows us to define as "not creative" ideas with little to no novelty and ones that appear to have zero chance of being successful. It allows us to place ideas on a scale of more or less creative depending on how much novelty they have and how likely they are to be a success (and how great the impact will be if successful). In looking at practical implications such as educational creativity (Smith & Smith, 2010), it allows us to focus on working with students on the generation of ideas and to check to see if those ideas are within reason (have a chance of success). In considering this, it highlights the notion that for students, idea generation and quality checking are very different activities. Do we want to teach them in tandem as a more wholistic approach to creativity instruction, or separate them out and work on building each notion separately, worrying about their integration at a later date?

From a different perspective, this approach to creativity explicitly does not include notions of the pursuit or execution of ideas, nor the promotion of ideas to specific audiences or the general public. Those are critical aspects of being successful in society, but to our minds, they fundamentally have little to do with creativity. Think Emily Dickinson. We would like to include her poetry as residing well within our notion of creativity although she did very little to promote her work. Creativity is the process of coming up with good ideas. After that, one is engaged in other activities.

This definition of creativity also speaks to questions about art and literature. We think Emily Dickinson's poetry meets the criterion of creative because of characteristics of her work (slant rhymes, punctuation, general break with poetic traditions of the time). We also think it is beautiful and dramatic, but that is different from being creative. In this model, art can be excellent without being creative. Creativity is not everything that is beautiful, wonderful, useful, moving, or sensitive. Sometimes it is simply, "the best bad idea we have."

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Chapter 3
The Difference That Makes a 'Creative' Difference in Education

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Abstract The perspective of creativity as rooted in difference opens up new questions for researchers and educators concerning the sharing of perspectives and, most importantly, the role of contradiction between perspectives within the educational act. While differences of perspective between students, teachers, or students and teachers, can be considered a precondition for the emergence of new and valuable ideas or practices, this condition is necessary but not sufficient. The process of engaging with difference in a productive or creative manner includes,being aware or, recognising, and valuing different perspectives, but this process itself doesn't explain how exactly novelty emerges in classroom settings. Furthermore, not any kind of difference fosters creativity under any circumstances. What type of difference is favorable for creative action in educational settings? The present chapter addresses this question based on a series of theoretically-informed empirical examples.

3.1 Introduction

Difference is not only fundamental for the 'fruits' of creativity but it also stands at its 'root' (Glăveanu, 2015a; Glăveanu & Gillespie, 2014). Indeed, difference has long been thought of as a core feature of the creative process. The combination of different (even opposing) stimuli has served as the basis for various prominent models of creative cognition (Rothenberg, 2014; Ward & Kolomyts, 2010). Moreover, we often think of creative products as different, one way or another, from what already exists. The 'size' of this difference (often understood as degree of originality) is even taken as a key marker of creativity itself (see Runco & Charles, 1993). Although difference traditionally has been conceptualized as an attribute of creative persons and products, there is growing recognition that difference might be more

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fruitfully conceptualized as a social and cultural phenomenon (Glăveanu & Gillespie, 2014; Pelaprat & Cole, 2011). This perspective highlights how difference is not a static feature of people and objects. Rather, difference is a dynamic, situational feature of everyday social contexts and encounters, including the contexts and encounters found in schools and classrooms. The question, then, is not whether students and teachers experience difference in educational settings, but rather what type of difference is favorable for creative action in those settings? The purpose of this chapter is to explore this question. More specifically, we attempt to highlight and untangle the role that difference plays in both creativity and education. We also highlight key tensions and contradictions that can support (or inadvertently undermine) students' and teachers' ability to creatively act on the difference afforded to them in the day-to-day classroom. We close with a brief discussion of future directions for research and practice.

3.2 Varieties of Educational Difference

Difference is a ubiquitous feature of school contexts. Even highly formal and somewhat prescriptive educational settings afford students and teachers with opportunities to encounter and experience different ideas and perspectives. There is, for instance, a clear and socially instituted difference between teachers and students. Societies have established scripts and well-defined positions for teachers and students, scripts and positions that are represented in sociomaterial arrangements of the classroom. More specifically, the material arrangement of the objects of the classroom (desks, chalkboards, screens, computer projectors) establishes hierarchical relations whereby teachers are positioned as holding expert knowledge that needs to be acquired and reproduced by students.

At a more basic level, students and teachers have different personal and cultural experiences that shape their worldviews, interests, and types of knowledge. This applies as well, of course, to students and teachers taken separately. Given these individual and socio-cultural differences, no two students are ever completely alike. Different students have different interests and strengths and they are assigned different 'roles' within the dynamic of the classroom (i.e., the "know-it-all," "bully," "teacher's pet," "class clown," "scape goat," etc.). The material resources available and how they are used also influence social relations and experiences in classrooms. These differences can be observed in different classrooms between schools and regions and even in different classrooms within the same school. Two teachers in the same school, teaching the same subject area, can for instance differ substantially in how they use resources. One teacher relies entirely on a textbook and materials provided by the text book company to design and deliver lessons. The other uses a blend of internal and external resources to design lessons (e.g., the Internet, student interests, and the various sociocultural and material resources found in the local community). Last but not least, there are clear differences between education as it was performed decades ago and its profound transformation today under the influence of information technologies and globalization processes. What is the future of education? And how are the differences we notice between what education was, is and what it could or should be and how are they used to shape current classroom practices?

Illustrated above are a few key types of difference that permeate all classroom contexts at all times: the difference between self and other, between person and material setting, and between past, present and future arrangements (Glăveanu, 2014, 2015a). The basic value of such differences (and many others) for education can be easily revealed by simple thought experiments (see also Glăveanu, 2015b). How would a classroom look without different social roles such as those of teacher and student? Without differences of knowledge and opinion between the participants involved? With the same material conditions and the same understanding and use of these materials? With no perceived difference between how things were done, are done, and will be done in the future? Collapsing differences would bring perhaps stability and uniformity, but it would certainly exclude change and creativity. It is because of experiencing difference that we are confronted with a challenge in our understanding of and action in the world, a challenge that is at the root of creative expression. To be sure, these differences don't always lead to creative outcomes. Teachers might be very much aware of the fact that their students see the world differently than they do but either ignore or reject such difference; indeed, many criticize the unidirectional movement of traditional education, whereby the knowledge and views of the teacher are transmitted to and shape student's knowledge and views (Beghetto, 2013a). Or, to take another example, noticing a difference between how education was carried out in the past and what it is today might lead some teachers and parents to lament the loss of valuable educational ideas and practices rather than contribute to their renewal. This effort to level difference out while living in a world of difference does require its own 'creativity', but this is another topic of discussion. For the moment we can conclude that difference is a *necessary but not sufficient condition* for creativity to occur. More than this, we can notice that the ways in which we notice difference (or not), we recognize and legitimize it (or not), and act upon it (or not), foster (or block) creative action within and outside the classroom. In short, difference is experienced in varied ways across various educational contexts. On one end of the continuum, we have educational settings that suppress difference and, thereby, undermine opportunities for creative thought and action. On the other end of the continuum we have educational contexts that are more supportive of acting on difference and, in turn, help foster creative thought and action.

3.3 Erasing Difference: Privileging Sameness

Although we have just asserted that difference is *always and already* present in all educational settings, we also recognize that schools have been used to systematically suppress and, in some cases, eliminate difference. The American Indian

Boarding schools of the late 1800s and early 1900s, for instance, represent some of the most extreme and tragic examples of this. As Adams (1995) has explained:

> From the policymakers' point of view, the *civilization* process required a two fold assault … [1] the school needed to strip away all outward signs of the children's identification with tribal life…[2] the children needed to be instructed in the ideas, values, and behaviors of white civilization…the boarding school was designed to systematically carry out this mission.

The explicit assimilationist aims carried out by the American Indian Boarding Schools serves as a disturbing (and recent) reminder of how an emphasis on sameness – when taken to the extreme – can manifest in cultural genocide. Although the prototypical model of schooling in the twenty-first century is not characterized by such explicitly brutal assimilationist aims, there are still features of the modern schooling experience that emphasize and privilege sameness.

Students, for instance, are typically grouped in the same classroom with same-age peers, provided with the same learning materials, and exposed to the same curricular topics at the same time, in the same place, and with the same teacher. Why might this be the case? One reason is because standardization can be appealing to designers of complex systems like comprehensive public schools. Consider, for instance, the design of public schooling during the early twentieth century in the United States. During that time, the designers of public schools were heavily influenced by the industrial-age logic of standardization (Schank, 2004). Specifically, standardization was viewed as one of the most efficient and feasible ways to manage the complexity of mass schooling. Moreover, because a primary goal of school was to prepare young people for the world of work, it was believed that minimizing differences between schools and factories would ease the transition from school to work.

The standardization of early twentieth century Schooling whereby "all students were to memorize and master the same core curriculum" was, according to Sawyer (2010), "reasonably effective" at easing the "transition from school student to factory worker" (p. 176).[1] Although modern day curriculum designers no longer view preparing students for factory work as a primary goal of education, several curricular writers continue to emphasize the virtues of sameness. "Teaching for sameness" is, for example, viewed as one way to help reduce the complexities of teaching and help learners make conceptual connections between differing tasks. Consider, for instance, the following excerpt from *What works in Schools: Translating Research into Action* by Robert Marzano[2]

[1] It is important to point out that Sawyer is not an apologist for standardization. Rather, he was simply explaining one reason why standardized practices took hold in U.S. schools. In fact, he also asserts that the standardized model of schooling is "particularly ill-suited to the education of creative professionals who can develop new knowledge and continually further their own understanding" (p. 176).

[2] Marzano is one of the United States most popular educational consultants and writer of professional development books aimed at classroom teachers and school administrators.

> In short, learning is enhanced when students are presented with tasks that are similar enough for them to ascertain their sameness (2003, p. 12).

The importance of sameness is further underscored by Douglas Carnine (cited in Marzano) who writes,

> If sameness is the psychological key for organizing curriculum, the content itself must be the lock. The mechanism that allows the lock to function is the organization of the content in ways that highlight important sameness (p. 12).

Finally, Ellis and Worthington (1994) assert that teaching for sameness is a key principle of effective teaching. Paraphrasing the work of Edward Kameenui, Ellis and Worthington assert that teaching for sameness can help:

> (a) eliminate students uncertainty about a new and relatively unknown topic, (b) assist students in making associative links in their cognitive structures, and (c) teach more in less time (p. 73).

The logic of "teaching for sameness" can be summarized as follows: If teachers structure the curriculum to make sameness salient, then students will have consistent and explicit exposure to the concepts and skills that teachers intend for them to learn; which, in turn, will help them develop the ability to identify those concepts and skills in varied examples, and ultimately allow students to transfer their school-based learning to out-of-school applications.

This logic has appeal to it. It can help allay anxiety that teachers feel when faced with the sheer enormity and uncertainty of the pedagogical task they face. It can also help structure a seemingly chaotic array of difference. Moreover, it serves as the basis for popular instructional design strategies, such as *backwards planning*.[3] These strategies encourage teachers to identify fixed outcomes and work backwards to design the steps that students need to take to attain those outcomes. The potential universe of different outcomes and different ways at arriving at those outcomes is thereby reduced into a clear and efficient path for teachers and students to follow.

The problem with such an approach is that difference is positioned as a potential inefficiency or distraction. Teachers may therefore feel compelled to design such distractions out of their lessons and dismiss them when they arise during the act of teaching. In such an arrangement, students are positioned as more or less "successful" based on how well they are able to *match* the teachers' predetermined expectations. Students who have similar sociocultural and historical experiences as their teachers are at an advantage in such an arrangement because they are more likely to be able to match what their teachers expect and how they expect it (Beghetto, 2016).

Learning and life are, of course, never that tidy, clear, or precise. There is always surplus difference (even in seemingly aligned conceptions between people). Moreover, as we have already asserted, the surplus in how people experience and understand events is rich with creative possibilities. Anyone who has ever taught

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[3] Backwards planning is an instructional strategy that is also called "backward design" and is often attributed to the work of Wiggins and McTighe (2005). Wiggins and McTighe outlined a three stage process for designing lessons (i.e., identify desired results, determine acceptable evidence, and plan learning experiences).

recognizes that even in the most tightly planned of lessons, difference always emerges. There is always a difference between the lesson-as-planned and the lesson-as-lived (Aoki, 2005; Beghetto, 2013b). Moreover, teachers who have spent time reflecting on and dwelling in those encounters with difference can recognize the generative possibilities that inhere in such moments. Consider Vivian Paley, the early childhood educator and author, who beautifully describes how her perspective changed when she reflected on such "distractions":

> In my haste to supply the children with my own bits and pieces of neatly labeled reality, the appearance of a correct answer gave me the surest feeling that I was teaching.... [I] wanted most of all to keep things moving with a minimum of distraction. It did not occur to me that the distractions might be the sounds of children thinking (Paley, 2007, p. 122).

How then might we conceptualize an educational environment that views difference as an asset? What would it mean to act on (rather than minimize) difference?

3.4 Acting on Difference: Making and Taking Perspectives

From our standpoint, creativity can be defined as *a process of recognizing, valuing and acting on difference within concrete material and socio-cultural settings*. But what are we actually acting on when working through difference? To understand this better we need to introduce another key notion for our discussion – that of perspective (Glăveanu, 2015c). Perspectives are relational in that they relate the person with something else in the world. Perspectives thus 'bridge' the difference between the one who constructs the perspective and the object, person, or phenomenon the perspective is about. Students develop perspectives regarding their teachers, colleagues, including perspectives on themselves as participants in the educational act. Equally, they have certain perspectives when it comes to the objects that surround them as well as the educational system as a whole and its evolution over time. Important to notice, these perspectives shouldn't be understood simply as ideas or mental constructions (of self, others, school, etc.) but action orientations (Gillespie, 2006). Indeed, any perspective fundamentally designates a way of relating to other things, people or situations and this relating is both grounded in and conducive for human action. Since perspectives actively construct the world for us, they also reveal our potential for acting within this world and orient us towards it in a particular way.

To take a hypothetical (but not uncommon) example, let's imagine a student's perspective of math classes as being difficult. To begin with, this perspective mediates the relation between person (student) and context (math class). This context includes other people (the math teacher, for example), certain material arrangements (i.e., tools used to solve math problems), and certain temporal orientations (i.e., 'I have never been good at math and will never be'). More than this, the perspective constrains the student's area of possibility for action, in this particular case a restriction of possibilities when it comes to mathematics. This perspective is not singular, however, but exists within a plural universe of perspectives within which the math teacher might be ‘scary’, math homework ‘tiring’, parents’ expectations ‘exaggerated’ and colleagues good at math ‘nerds’. Most importantly, these perspectives are also in dialogue with those of others. What does the math teacher make of our student? And how does his or her perspective relate to that of the student? Is there perspective-taking involved, on both the side of student and teacher, or they do not communicate with each other, even clash? And, if they clash and exclude each other, what is the chance of reaching a creative outcome in the relationship?

Creativity and perspective-taking are deeply inter-related processes (Glăveanu, 2015d). This is so because perspective-taking allows one to take distance from one’s position in the world and see both self and world through the eyes of an other (i.e., as an other person would). Of course, there is an imaginative dimension involved in this process as one can never, literarily, ‘take’ the perspective of an other (i.e., become an other). However, perspective-taking is not a fully fictional process either but one grounded in our social and physical experience of the world. As children, for example, we often exchange positions during play episodes becoming, recurrently, the doctor and the patient, the hider and the seeker, the thief and the policeman, etc. (Gillespie, 2012; Gillespie & Martin, 2014). This embodied exchange is not reserved to childhood however. As adults, we often experience changing roles such as speaker and listener, teacher and learner, care-giver and take-care, so on and so forth. In fact, if we get the chance to participate in creativity workshops, we might use this process through role-play or techniques such as the Six Thinking Hats (de Bono, 1987). Why is perspective-taking used to stimulate creativity? It is precisely because, when adopting the position of an other we get to see and understand more about our current situation. In this sense, perspective-taking is one key process leading to an expansion of experience (Zittoun & Cerchia, 2013), allowing us to notice alternatives, construct hypothetical scenarios, and make our actions more flexible.

In addition, the capacity to ‘take’ the perspective of the other is a momentous achievement in human development and is discussed at length by social and developmental scholars. For Piaget (1954), de-centration allows the child to overcome an egocentric, self-centered perspective and facilitates the development of abstract forms of intelligence. For Mead (1934), the birth of a human self and reflexivity relates to the possibility of seeing oneself as other person would. This includes being capable of taking the perspective of the ‘generalized other’, of society, making us sensitive to what is expected of us in a given situation. However, society is never monolithic but made up of a variety of persons, groups and, more importantly, various social positions. Bakhtin (1981) makes this point clearly in his dialogical approach to society and mind, in which a multiplicity of voices (polyphony) defines our use of language at every moment. Applying these theories to the area of education we can think about the possibility, for teachers and students alike, to take the perspective of the other. What would happen if the student afraid of math classes would try to understand the position and perspective of the math teacher? How would the class look from this perspective? What kind of new insight or understanding might emerge, if the math teacher understood his/her class as a (frightened) student does? What kind of teaching methods and strategies would we develop from this symbolic form of position exchange? Above all, how easy or hard is it for teacher and students to take each other's perspective in order to mediate the difference between their positions?

This is a question that leads us not only to issues of ability and practice, but most of all to questions related to social relations and culture. Let's begin by reflecting on the first. The social field of relations, including in educational contexts, is not a 'flat' universe of horizontal connections and dialogues. On the contrary, just like most human contacts, the school is marked by power relations and hierarchies that make certain perspectives dominant and legitimate, while marginalizing or even excluding others. Institutionalized arrangements prioritize, for example, the perspective of teachers over that of their students. The school curriculum is, in practice, set by adults with little or no input from students. This practice speaks not only about particular inter-personal relations (student – teacher), which can vary from case to case, but also about the societal position of children as 'un-finished' persons (D'Alessio, 1990), as becoming rather than being. The general 'deficit model' of childhood (Shaw, 1996) permeates developmental and educational models within both psychology and education: one can even think here about Piaget's (1963) linear development of intelligence in which children progressively move from lower to higher levels of ability and understanding. This type of positioning doesn't value children's voice as competent or legitimate and it carries wide repercussions in education and in the public sphere. If, going back to our example, the child doesn't do well in math, what is typically listened to is the perspective or point of view of the teacher, the parents and even the school as an institutions in order to make sense of the situation. How often is it for the perspective of the child to come to the fore? What kinds of resources for creativity are being missed here due to these asymmetric relationships?

3.5 Openness to Difference

This is a good moment to recapitulate our argument so far. We started by placing difference (between self and other for example) at the root of creative expression. Such difference is a necessary but not sufficient condition for creativity to emerge. Rather it is *acting on difference* that generates novelty. But how do we act on difference? By building and putting in dialogic perspectives that bridge (or, on the contrary, widen) difference in educational settings. Perspective-taking is a process particularly useful for creative action since it can open us to new possibilities of understanding the world as other people do. However, perspective-taking as a way of bridging difference cannot be taken for granted in everyday interactions. There are not only individual differences that we might consider here but we need to be sensitive as well to the greater socio-historical context of relations between individuals, groups and communities. Asymmetries and relations of power make certain perspectives salient while silencing others both within and outside the classroom. These mark the way we construct otherness and constrain our openness towards new perspectives which, at a minimum, disturb our feeling of certainty or violate our expectations and, at times, deeply shake our convictions and make us question our chosen path. The question, for education, is how exactly we can cultivate these processes of embracing otherness and difference that are so central for creativity.

This leads us to introducing a final notion, that of *openness to difference* (OtD). In general terms, we use this concept to designate *those situations in which differences in perspective are made salient and experienced in ways that lead to the emergence of new ideas, objects, or practices*. From the beginning it is important to note the fact that openness to difference is not entirely intra-psychological or mental property or trait. We are well familiar, for instance, with the long tradition in creativity studies of focusing on openness to experience as a possible predictor of creativity (Kaufman, 2013; McCrae, 1987). There certainly is a conceptual connection between these two ‘types’ of openness (as, in fact, difference defines our experience). However, and this is a crucial aspect, for us OtD is a construct that applies to a fusion between people and situations, what might be called *people-situations*, rather than people and their situations (or even situations and their people). In this sense, it includes an assemblage of persons and their relationships while placing both within socio-material and historical contexts that structure their (physical and symbolic) positions and the relations between them. At the same time, openness to difference is a dynamic construct in the sense that it is never given it advance but constructed within the situation.

Going back to the example of the classroom, we can ask whether the classroom setting itself can be defined as one marked by openness to difference and this is a legitimate question in its own right. Our interest though is more micro-genetic. We are primarily concerned with how OtD is constructed within moment-to-moment interactions between people, in this case, between participants in educational contexts. This represents a much more dynamic conceptualization of creativity-in-context (see also Beghetto, 2016; Tanggaard & Beghetto, 2015) than what creativity researchers have typically considered (e.g., focusing on more static features of creative people, places, and products). Second, by using the notion of openness to difference we want to emphasize the fact that the existence of difference itself is not enough. Indeed, as we have already noted, difference is always and already a feature of every social arrangement. People therefore need to acknowledge, value, and act on different perspectives in order to realize the emergent and creative potential of difference.

It is interesting to notice here that, within everyday contexts, we often take the views of the other into account without fully engaging with them. Alex Gillespie (2008) discussed in this regard the notion of alternative representations and pointed to the ways in which other positions and views are reflected in discourses just to be quickly dismissed (through rigid oppositions, transfer of meaning, undermining of the motive, bracketing, and so on). An authentic engagement with difference is specific for what Jovchelovitch (2007) defined as *dialogical encounters* between people and their knowledge systems. Such encounters are characterized not only by mutual recognition but also by mutual respect. Non-dialogical encounters, on the other hand, are based on strict hierarchies that dismiss the position of the other as a way of enforcing the superiority of one's own position and view of the world.

3.6 Openness to Difference in the Classroom

What features of classroom situations might encourage (rather than suppress) openness to difference? This is an important question both for researches and practitioners. For researchers, the question requires us to consider how OtD might be observed and studied. For practitioners, the question requires us to consider how OtD might be cultivated or encouraged. In short, addressing this question will help us take a step toward understanding, classifying, and possibly nurturing OtD in different classroom arrangements. Where might we begin? One place to start is to recall that perspective plays a key role in OtD. As we discussed, OtD requires acknowledging and engaging with differing perspectives. There are many classroom situations in which differing perspectives are at play. Classroom discussions serve as a particularly promising example. In fact, classroom discussions are one of the most common instructional strategies used by teachers (Cazden, 2001). Moreover, teachers typically use classroom discussions as a means for inviting students to share and engage with different perspectives and insights.

Of course, not all classroom discussions are supportive of differing perspectives. Indeed, they can be used as a vehicle for moving participants toward adopting a more singular perspective. Even in discussions where students are invited to share their perspectives, there is always the risk that such perspectives will be dismissed in favor of more narrow or what might be called *monocular* perspectives. It therefore might be helpful to think of classroom discussions ranging along a continuum.

On one end of the continuum we might have discussions that emphasizes a *monocular* perspective and on the other end *polyocular* perspective. In the sections that follow, we will briefly define each perspective and discuss two classroom examples.[4] Prior to doing so, we want to caution against viewing monocular and polyocular perspectives as static or fixed categories. We would assert that even in seemingly rigid monocular situations, there are still polyocular features and ruptures that can (and do) emerge (cf. Beghetto, 2013a). Put another way, the potential to engage with difference is always present in any educational encounter. In predominately mon-

[4] The classroom examples that we drawn on are based on footage from actual classroom discussions (Hannah & Abate, 1995; Kamii, 2000). These examples have been used elsewhere to illustrate features of classroom interactions between teachers and students that are more or less supportive of creative expression (see Beghetto, 2013a, 2013b). In the context of the present chapter, we elaborate on the previous use of these examples to illustrate monocular and polyocular features of classroom encounters.

ocular situations, however, we would expect to see less recognition of and openness to difference.

Finally, given that OtD is a dynamic feature of *people-situations*, it is not sufficient to attempt to classify a classroom and the people who populate that situation by measuring static features of a classroom or more or less stable personality traits and dispositions of students and teachers. Rather, we would argue that it is important to consider the microgenetic or moment-to-moment features of classroom interactions. This requires acknowledging the temporal dimension of such interactions. In this conceptualization, time, is not a variable to be controlled or manipulated, but recognized as a contextual and inextricable feature of the classroom situation (Cf. Tateo & Valsiner, 2015). Indeed, classroom discussions are dynamic situations that move students and teachers into various encounters with difference. Even in the most monocular dominant situations, polyocular ruptures can (and often do) occur, but tend to collapse back into a more singular perspective. Similarly, in more polyocular situations, there are still singular perspectives put forth, however, the situational features of the encounter encourage taking differing perspectives and even changing previously held perspectives. The following sections provide further discussion and actual classroom examples to help illustrate these assertions.

3.7 Monocular Dominance

In the context of a classroom discussion, monocular dominance refers to a classroom arrangement that enforces and privileges one perspective, typically the teacher's perspective. In such an arrangement, teachers use their positional power to funnel different student perspectives into a more singular or monolithic perspective. In monocular situations, the teacher's perspective is experienced as somewhat fixed and predetermined. When differences emerge, teachers work to resolve those differences by attempting to move students' perspectives into alignment with their own perspective. The "learning" that happens in such an arrangement tends to be unidirectional (only students are the learners) and aimed at helping students align their perspectives with that of their teacher. Difference is viewed as an unnecessary surplus and thereby dismissed or discounted.

We also recognize that teachers are not the only people who might adopt a monocular perspective during classroom discussions. Students can also hold rigidly to a particular idea or perspective (e.g., "This is the way it is because my parents told me so"). Student's can also dismiss the perspective presented by the teacher by focusing on "unsanctioned" (Matusov, 2005) side-discussions with peers (e.g., having a side-discussion about the upcoming school dance, who is dating who, last weekend's football game) or by focusing on "unsanctioned" objects (e.g., texting on their phone, playing with a small toy from home, reading a comic book during the lecture).

Finally, as we have discussed, the dominance of a monocular perspective in such situations is not the result of teachers possessing a tyrannical personality trait or the result of a fixed environmental feature of the classroom. Rather, we would assert that monocular dominance results from a *confluence* of situational and personal factors (e.g., the sociomaterial arrangement of the classroom; the inherited rules, norms and scripts of the context, the roles assumed by the participants in that situation, and so on). At this point, an example from an actual classroom dialogue may help illustrate.

3.7.1 Monocular Dominance in the Classroom: Example 1

The following excerpt is from video-footage of a sixth grade science lesson (Hannah & Abate, 1995). In this excerpt, the teacher is reviewing the definition of a hypothesis (a concept that has been previously introduced to the students) prior to engaging students in a hypothesis testing activity:

Teacher: I need someone to tell me what a hypothesis is.
Student: A what…a what?
Teacher: [stressing each syllable] A Hy – Poth – E – sis. What do you THINK that word is? We have talked about it a little bit before. Andrea, what do you think it means?
Andrea: [softly] A plant.
Teacher: A plan. That's a good guess…
Andrea: [louder] Plan-T.
Teacher: A plant!? *[look of surprise]* Ok, we'll put that up. *[writing "plant" on the chalkboard].* I'm going to put every answer up and we'll try to see…what we've got. What else, Tim?
[After several more students share their ideas the teacher calls on a student named Rob]
Teacher: Rob what do you think?
Rob: I think it's a kind of idea.
Teacher: Ok, kind of an idea…I'm gonna stop right there 'cause Rob did come up with it…

We might classify the above interaction as monocular dominant. Although differing perspectives are explicitly invited and even written on the board (i.e., "What do *you* think this word means… I'm going to put every answer up and we'll try to see…what we've got), the purpose of these invitations does not seem to be focused on a willingness to actually encourage or explore different perspectives. Indeed, even though differing perspectives are elicited and even written on the board, the teacher and students never fully explore or return to those perspectives in an effort to understand them. Rather, the teacher seems to be using her invitations for students to share their perspective as an effort to align or collapse those perspectives into a more monocular and predetermined perspective. She signals this intention in her responses (e.g., look of surprise, "We have talked about it a little bit before"; "I'm gonna stop right there 'cause Rob did come up with it…").

We recognize that in a situation such as attempting to quickly review a previously introduced concept, a more closed pattern of interaction is not uncommon and may even be justified (cf., Cazden, 2001). Still, even in such situations, we would argue that the potential benefits from even briefly exploring differing perspectives are lost because such perspectives are viewed as leading to potential confusion (e.g., obscuring the clarity of the view the teacher is trying to get across). Consider, for instance, the moment in turn 6 of the above dialogue. In that moment, Andrea disrupts the monocular momentum of the interaction by "speaking out of turn" and stating that what she actually said was "*plant*" not "*plan.*" As has been discussed elsewhere (Beghetto, 2013a, 2013b), this rupture represents a micromoment opportunity. Andrea presents her teacher (and the entire class) with a subtle opportunity to engage with a different perspective. In this moment the teacher has several options, including deciding to briefly explore this perspective or dismiss it.

In the above excerpt, the teacher chooses to write Andrea's response on the chalkboard. However, because she never returns to the response, writing it on the chalkboard is actually a way of gently dismissing it. Moreover, because the teacher eventually states that Rob "did come up with" the perspective she was looking for, Andrea's perspectives (along with the other responses on the board) might be viewed as unacceptable and eventually erased (literally and figuratively) from the interaction. This pattern of interaction can establish situational norms of engagement that reposition teacher invitations for students *to share their perspectives* as actually a request for students *to align their perspectives* with that of their teacher. Consequently, any potential benefits that might come from exploring differing perspectives are likely to be lost.

What if, instead, the teacher took time to engage with Andrea's perspective? Doing so might reveal a large universe of possibilities. One possibility might be that Andrea made an association with the term photosynthesis because it sounded similar to hypothesis. Exploring such an association, even though it might initially seem "incorrect," could still yield generative possibilities and discussions. Yet another possibility might be that Andrea was attempting to share a prior learning experience she had (e.g., "Last year, I used a plant to test a hypothesis. I hypothesized that different amounts of water would…"). Unfortunately, when different perspectives are immediately (even if gently) dismissed, the possibilities for new thinking and action are lost (Beghetto, 2013a). We therefore assert that classroom discussions that encourage and explore polyocular perspectives (even in the context of a more monocular arrangements) can result in generative possibilities.

3.8 Polyocular Opportunities

We define polyocular opportunities as situations that encourage and reinforce perspective taking. In such situations, difference is encouraged and respected–even when those differences represent disagreements and breakdowns in understanding. Polyocular situations encourage people to engage with differing perspectives in a good faith effort to understand those differences. When this happens the difference can serve as a catalyst to transform one's and others' perspectives, and in turn, result in creative thought and creative action. In the context of polyocular classroom discussions, teachers are conscious of the tendency of interactions to collapse into monocular perspectives and thereby actively work to elicit and encourage engagement with differing perspectives. An example may help illustrate.

3.8.1 Polyocular Opportunities in the Classroom: Example 2

The following example is drawn from Kamii's (2000) video footage of second graders working through a double-column addition problem. This

Teacher: *[Writes 87 + 24 on chalkboard, waits 20 seconds and then calls on a Student]* Celici?
Celici: Hundred and one.
Multiple Students: *[loudly]* Disagree! Disagree!
Teacher: Brian what did you get?
Brian: Hundred and ten.
Multiple Students: *[loudly]* Disagree! Disagree! Disagree!
Teacher: Jaycee?
Jaycee: Hundred and eleven.
Multiple students: *[loudly]* Agree! Agree! Agree!
Teacher: Okay. Who wants to try to explain how to get the answer? Alright, Jaycee?
Jaycee: I know that eighty and twenty is one hundred. And then I knew that six and four was ten. So I took the seven and four and that made eleven…hundred and eleven.
Multiple Students: Agree. That's how I did it…
Brian: I disagree with myself.
Teacher: You disagree with yourself? Which do you think it is now, Brian?
Brian: Hundred eleven.
Teacher: Okay. Celici, what about you? Do you still think it's …
Celici: Hundred and eleven.
Teacher: Okay, let's go on to another.

We would classify the above interaction as polyocular. Even though the math problem has one correct answer (i.e., 111), students actively and vigorously engage with differing perspectives and approaches and consequently are able to see and understand the problem in new ways. The teachers seems to be aware of her situational power and thereby uses her positional role to elicit and facilitate engagement with differing student perspectives (rather than impose her perspective). This results in a situation in which students share their perspectives (e.g., "Hundred and one", "Hundred and ten"), actively disagree with each other (e.g., "Disagree! Disagree!") and, most importantly, publicly disagree with themselves (e.g., "I disagree with my self"). In such an arrangement, students are encouraged to actively (and passionately) share and consider different perspectives on a particular object of interest (in this case, a double column addition problem).

When this happens, difference can serve as a catalyst for not only seeing something in a new way but can actually transform one's prior understanding ("I disagree with myself"). Of course, it might be the case that in some arrangements students may feel the pressure to simply acquiesce to a prevalent perspective (even though they do not share or understand it). This is where teachers (and peers) can play a key role in gently checking in with the students, as the teacher did in the above excerpt

("You disagree with yourself? What do you think it is now…"). Cultivating openness to difference, however, goes well beyond a set of strategies used by teachers or a particular set of dispositions held by teachers and students. We would assert that OtD is manifest in situational norms that become established through the opportunities, encounters, and effort put forth by students and teachers to take, share, and even abandon different perspectives. It is only through frequent and active engagement with difference that OtD is supported in classroom discussions amongst teachers and students.

In sum, the kind of difference that makes a difference in student learning and classroom creativity is one in which new and personally meaningful (i.e., creative) perspectives can be shared and thereby contribute to the learning and understanding of others (Beghetto, 2016). In this way, both teachers and students have opportunities to share and potentially transform their own and each other's perspectives.

3.9 What Difference Makes a 'Creative' Difference?

We now to return to the question we set for ourselves in this chapter. If difference is a necessary but not sufficient condition for creativity and not every kind of difference at any particular time is productive for creativity then we can legitimately ask what difference makes a 'creative' difference. This question is all the more importance since, if we are to agree with the relation we postulated here between creativity and difference, then we need to ask ourselves how many moments of experiencing difference are lost and end up being missed opportunities for both learning and creativity (see Beghetto, 2013a, 2016).

Unfortunately, as the illustrations we offer in this chapter come to show, this question cannot be answered in a definitive way or, rather, in a universal manner. There is no absolute set of guidelines that pre-define which differences 'work' and 'do not work' for creativity. However, having said this, there are some clear prerequisites for instituting a situation defined by us here as openness to difference:

Pre-requisite 1. To begin with, openness to difference thrives in contexts defined by *a plurality of co-existing perspectives*. Classrooms are, by definition, such contexts. It is not only that classrooms include a multitude of people, each with their own life trajectory and particular experience of diverse socio-cultural contexts, but they necessarily put their perspectives in relation to each other. This is a consequence of the multiple communication processes and forms of interaction instituted within school settings;

Pre-requisite 2. These settings need, in addition, to *cultivate sensitivity to otherness and difference*. Well intended, but misguided, efforts to "focus on commonalities among people" can impose a view of educational practice that tries to be blind to difference and collapse it into sameness or monocular dominance. The fear that difference might lead to prejudice and discrimination obscures the reality of omnipresence and its potential to be the engine of learning and creativity. True sensitivity to difference keeps the tension between self and other productive for both without creating hierarchies and power asymmetries between them;

Pre-requisite 3. The third essential condition relates to *valuing difference of perspective* as a resource for creative work (polyocular opportunities). This implies not only recognizing different, even opposite perspectives from one's own, but trying to consider the situation from their position and in their terms. Such an exercise in perspective-taking is not meant to replace one's perspective with that of an other but to stimulate reflexivity and the development of a creative meta-position from which different perspectives are placed in dialogue (Glăveanu, 2015d; de Saint-Laurent & Glăveanu, 2015).

As such, in light of the above, we can conclude that all those differences that end up being observed, legitimized and valued are, at least in potential, 'creative' differences. In order to study such differences we need a contextual and micro-genetic type of analysis (Abbey & Diriwächter, 2008; Wagoner, 2009), one that is capable of capturing dynamic phenomena grounded in ongoing communication and interaction. Tanggaard and Beghetto (2015) have, for instance, introduced an approach that might be adapted for this purpose. Specifically, they introduced a diagramed approach to trace the movement of more or less determinate ideas along a temporal horizon. In the case of OtD, the focus would be on tracing how interactions in classroom discussion move in and between more monocular and polyocular horizons of perspective. Regardless of the specific method used, such an analysis would need to take into account the structural conditions (historical and institutional) that shape everyday interactions such as those between students or between students and teachers within the classroom. The opposite of openness to difference is closeness to difference. It is equally important for such analyses to understand this type of closeness and its particular conditions and consequences. More than this, we need to observe how openness and closeness co-exist within one and the same situation depending what kind of difference we observe and whose perspective we are focusing on. This raises important and difficult ethical questions for creativity researchers and educators: what perspective am I adopting in defining and constructing situations of openness to difference? Ultimately, what kind of openness and social responsibility do we have, as researchers and teachers, when it comes to building educational contexts that can be described, not only by us but our students as well, as open to difference, otherness, and creativity?

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Chapter 4
Avoiding Dogmatic Traps in Creativity and Education Through Awareness of Worldviews and Visual Metaphor

Don Ambrose

Abstract This chapter explores how misguided school reformers, the policymakers and citizens who believe those reformers, and the school systems and teachers obeying reform mandates often become trapped within a single worldview and think they are being creative. They might be creative to an extent but they are limiting their creativity by confining their thinking within a single root metaphor. The chapter discusses ways in which awareness of the worldviews and the use of visual metaphors can provide an opportunity for broader and deeper creative understanding of educational improvement.

4.1 Introduction

It would be difficult to find many rational adults who wouldn't want to see education improve. Teaching and learning are complex, dynamic processes that have not been perfected and likely won't be for quite some time, at least not at our current level of cognitive evolution. But school improvement and school reform are not necessarily synonymous. While school improvement is a worthy endeavor, most of what passes for school reform in today's neoliberal ideological climate is based on some combination of dogmatism and corrupt profiteering. Some reform advocates have good intentions but only a limited grasp on what learning entails. Others have very narrow, dogmatic conceptions of teaching and learning, analogous to the satirical characterization of nineteenth-century schooling embodied in the Dickensian character Thomas Gradgrind:

> Now, what I want is, Facts. Teach these boys and girls nothing but Facts. Facts alone are wanted in life. Plant nothing else, and root out everything else. You can only form the minds of reasoning animals upon Facts: nothing else will ever be of any service to them. This is

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> the principle on which I bring up my own children, and this is the principle on which I bring up these children. Stick to Facts, sir! (Dickens, 1854/1981, p. 1)

Still others view public education as just another profit-making opportunity and promote reform as a way to line their own pockets. These various reform initiatives tend to pressure school systems to implement excessive prediction and control through high-stakes testing that narrows the curriculum while imposing barren, robotic teaching methods and quasi-militaristic discipline on teachers and their students. These variations on school reform are explored in an increasing number of analyses (e.g., Beghetto, 2010; Berliner, 2006, 2009, 2011, 2012; Berliner & Glass, 2014; Fabricant & Fine, 2013; Horn & Wilburn, 2013; Kozol, 2005; Lubienski & Lubienski, 2014; Nussbaum, 2010; Ravitch, 2010, 2013; Zhao, 2009, 2014; Zhao & Gearin, 2016).

The unintended results (in many cases) or intended results (in some other cases) include a narrowing of the curriculum and the removal of intrinsic motivation and creative and critical thinking. There are some exceptions. For example, the Common Core standards in the USA make far more room for creativity than is commonly believed (Baer, 2016; Beghetto, Kaufman, & Baer, 2015). Nevertheless, even with a more thoughtful set of externally imposed standards, creativity in the education system suffers when reformers ignore other important influences on instructional effectiveness such as the pernicious effects of socioeconomic inequality (see Cross & Borland, 2013; Fabricant & Fine, 2013; Ravitch, 2010, 2013).

4.2 Metaphor and Dogmatism

Both creativity and school reform can react to the implicit influence of metaphor on the mind. Metaphor has inspired and shaped thought and action in a wide variety of academic disciplines, professional fields, and cultural arenas.

4.2.1 Research on Metaphor and Cognition

Dogmatism is the primary enemy of creative, ethical thought and action because it confines human minds to narrowminded, superficial, shortsighted perspectives on complex phenomena (Ambrose & Sternberg, 2012; Ambrose, Sternberg, & Sriraman, 2012). Virtually all of the enormous problems we face in the twenty-first century are caused by dogmatism (Ambrose, 2016b). Interestingly, one of the primary causes of dogmatism, and one of its most effective antidotes, is the use of metaphor.

Serious scholars tend to ignore metaphor, assuming that it is a playful tool used in high school and college English classrooms. Nevertheless, metaphor has been attracting the interest of researchers and theorists in multiple disciplines because they appreciate the ways in which metaphorical thought exerts powerful, implicit influence on theory, research, and practice. Metaphor frames the tacit understandings that underpin the structure and dynamics of cultures and academic disciplines (see Ambrose, 1996, 2000, 2012, 2014a, 2014b; Amin, 2009; Bowers, 1993; Bowers & Flinders, 1990; Boyd, 1993; Cohen, 2008; Eisenberg, 1992; Gibbs, 2008; Harmon, 1994; Holton, 1996, 1998; Johnson, 2009; Kuhn, 1993; Lakoff, 1993; Lakoff & Johnson, 1980, 1999; Larson, 2014; Osowski, 1989; Overton, 1984; Pepper, 1942; Schön, 1993; Sternberg, 1990).

Just a few examples of the impact of metaphor can facilitate understanding of the ways in which it influences perceptions of complex phenomena such as scientific discovery, environmental policy, and conceptions of intelligence. Metaphorical thought has been an extremely powerful shaping influence on scientific discovery. The prominent physicist/historian of science Gerald Holton (1996) articulated just a few of the metaphors that have inspired and guided scientific inquiry:

> …concepts such as the flow of heat or of electricity; of lines of force in the field; of all those metaphors, particularly the military ones in medicine–invasion, attack, defense–and elsewhere in the sciences, e.g., Darwin's Tree of Life, or the tangled bank; and before that, Newton's centers of attraction, his clockwork universe, and on and on.

Larson (2014), an environmental scientist, illustrated additional ways in which metaphorical constructs help scientists develop their understanding of scientific phenomena. However, he also discussed the flip side of metaphorical influence on science–its provision of dogmatic frameworks in social contexts that justify resistance to well-established environmental policies coming out of credible scientific work.

While working on clarifications of the nature of intelligence, Sternberg (1990; Sternberg, Tourangeau, & Nigro, 1993) engaged in large-scale metaphorical analyses of the conceptual frameworks for intelligence theory. He categorized an array of intelligence theories according to their alignment with various metaphorical frameworks including computational, epistemological, biological, geographic, anthropological, sociological, and systems metaphors. More recently, he used the metaphor of a drifting lifeboat to represent the ways in which ethical drift plagues otherwise intelligent individuals and groups within and beyond academia (Sternberg, 2012).

In addition, metaphor can be used as an effective tool for creative leadership because it captures the imagination of audiences and injects the leader's message with power and meaning (Charteris-Black, 2005). For example, Dr. Martin Luther King's "I have a dream" speech that catalyzed the civil rights movement featured frequent invocations of powerful metaphors such as "a lonely island of poverty in the midst of a vast ocean of material prosperity," "tranquilizing drug of gradualism," "rise from the dark and desolate valley of segregation to the sunlit path of racial justice," and "the whirlwinds of revolt will continue to shake the foundations of our nation until the bright day of justice emerges."

If metaphor has such a powerful influence on human thought in a wide variety of academic disciplines and in societal systems it likely exerts strong shaping influences on educational policy and practices. If so, falling prey to entrapment within a single, limiting metaphor could do considerable damage to teaching and learning, handcuffing talented teachers and stunting the growth of bright young people. But if we become aware of the metaphors that shape our thoughts about education we will gain some power over them and be able to use them as inspiration for educational progress as do the scientists who use metaphorical constructs to generate productive new theories and research agendas.

4.2.2 Metaphorical Worldviews

There are metaphors that shape small-scale decisions and then there are extremely powerful metaphors that make enormous impact on the world. Long ago, philosopher Stephen Pepper (1942) introduced academia to a set of the latter type of metaphor. He described the nature and impact of four root metaphors, which were known initially as world hypotheses and then became worldviews. The four worldviews include mechanism, contextualism, organicism, and formism. Each of the worldviews is based on a root metaphor, and includes a set of beliefs about the ways in which the world works. Here are descriptions of the four worldviews synthesized from Ambrose (1996, 2000, 2012, 2014a, 2014b):

Mechanism The root metaphor of mechanism is the machine. The mechanistic worldview portrays reality as machinelike so it's basic tenets include reduction of the whole into discrete component parts, a penchant for precision and appreciation of detail, a search for linear causal effects, and a striving for objectivity in research. Examples of mechanistic influences in the world include reduction of intelligence to an IQ score, the prominence of quantitative-empirical research methodology in the social sciences, and the predictability and precision of scientific management in manufacturing processes.

Contextualism The root metaphor of contextualism is an ongoing event within its context. The contextualist worldview portrays phenomena as unpredictably evolving and contextually shaped so it's basic tenets include magnification of the importance of context and the unpredictable emergence of novelty. Examples of contextualist influence in the world include the context sensitivity of complexity theory and the work of cognitive scientists who study the context-embedded mind, highlighting the influence of environment on cognition instead of confining human thought within the cranium.

Organicism The root metaphor of organicism is an organism developing through stages toward a particular end. The organicist worldview portrays phenomena as holistic, comprised of interacting systems within systems so it's basic tenets include the notion that the whole transcends its parts and the importance of long-term developmental processes. Examples of organicist influence in the world include developmental theories in psychology that highlight the integration of the affective, physical, and cognitive dimensions of human experience; the interdisciplinary synthesizing that takes place when scholars establish connections among diverse bodies of knowledge from various fields; and the teambuilding that occurs in organizations that manage to break down bureaucratic barriers.

Formism The root metaphor of formism is ubiquitous similarity such as that portrayed by Plato's ideal forms. The basic tenets of the formist worldview include the search for patterns of similarity in diverse phenomena. Examples of the impact of formism in the world include complexity theorists identifying patterns of similarity in the behavior of complex adaptive systems–for example, the ubiquity of the chaos-order continuum, which shows how complex systems tend to exhibit simple behaviors when they are excessively ordered or excessively chaotic, and highly complex behaviors when they strike a balance at the edge of chaos in the area of dynamic tension between chaos and order.

Much of Pepper's (1942) discussion of the root-metaphorical worldviews emphasized the importance of using more than one worldview conceptual lens to scrutinize and understand complex phenomena. Appropriately, he used an intriguing metaphor to convey the importance of employing multiple metaphorical worldviews when studying something complex:

> Post-rational eclecticism is simply the recognition of equal or nearly equal adequacy of a number of world theories and a recommendation to not fall into the dogmatism of neglecting any one of them.…Four good lights cast fewer shadows than one. (p. 342)

Overton (1984) later made similar points about the need for multiple worldview perspectives on psychological phenomena. Ambrose promoted the use of various worldviews in analyses of creativity theory (1996), the ethical and unethical behavior of the gifted (2000), the dynamics of the chaos-order continuum in complex adaptive systems (2014a), and combatting the dogmatism that plagues theory and research in most academic disciplines (2012). Gillespie (1992) argued that cognitive psychology could benefit from augmenting the important discoveries gleaned from mechanistic approaches with more attention to contextualist conceptual frameworks. Others made the same case for going beyond mechanism in special education (Dombrowski, Ambrose, Clinton, & Kamphaus, 2007; Heshusius, 1989) and gifted education (Cohen & Ambrose, 1993; Cohen, Ambrose, & Powell, 2000).

In yet another example, analyses of root-metaphorical worldview influences in education reveal some creativity-suppressing phenomena in classrooms and schools. Forsyth (2016) showed how the worldview preferences of students influenced the type of content they recall when reading history and science texts. In essence, the preference for a particular worldview conceptual lens in a student's mind magnified the importance of some content while obscuring other content.

These are just a few examples of the ways in which Pepper's four good metaphorical, worldview lights can cast fewer conceptual shadows. Figure 4.1 employs yet another metaphor to reveal the importance of the metaphorical worldviews. Here, each of the four worldviews is portrayed as one of four conceptual lenses rotating around the hub of a wheel that positions one metaphorical lens at a time

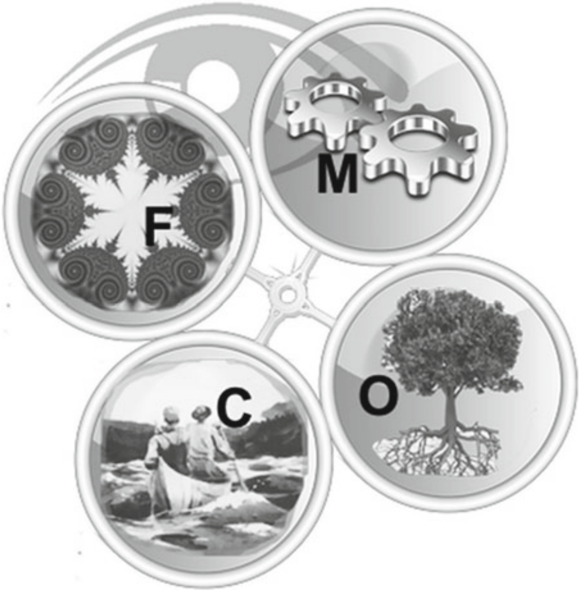

Fig. 4.1 The root metaphorical worldviews as conceptual lenses rotating over a human eye

over a human eye. The fact that only one lens at a time can cover the eye signifies the incommensurability of the worldviews. Pepper (1942) argued that the worldviews provide discrete perspectives on the world and tend to be incommensurable, making it extremely difficult if not impossible for the human mind to simultaneously entertain more than one worldview.

In Fig. 4.1 the mechanistic worldview is the upper right-hand lens, which includes mechanical gears signifying the precision, causality, and reduction of mechanism. The organicist worldview lens in the lower-right corner is portrayed by a tree and its roots signifying the holistic integration of subsystems and long-term developmental processes. The contextualist worldview in the lower-left corner is represented by canoeists paddling down a set of rapids signifying the importance of contextual influences (currents, waves, and wind) and the unpredictable emergence of novelty (capsizing or hitting a submerged rock). Finally, the formist worldview in the upper-left corner is portrayed by a fractal image to illustrate the repeating patterns of similarity in diverse phenomena.

If you are not yet convinced of the need for a strange cognitive apparatus such as the rotating worldview lens wheel in Fig. 4.1, the results of extensive analyses reported by the leading economist and complexity theorist Scott Page (2007, 2010) are worth considering. According to Page, cognitively diverse problem-solving teams in a wide variety of organizations have proven to be more effective than homogenous teams when it comes to complex problem solving. A problem-solving team is cognitively diverse if it encompasses diverse theories, philosophical perspectives, and problem-solving heuristics.

If we apply these findings about cognitive diversity to the worldview lens apparatus in Fig. 4.1, a cognitively diverse team would be able to creatively integrate discoveries from multiple perspectives as it rotates the worldview lenses on the apparatus across its collective eye, perceiving the world through mechanistic, organismic, contextualist, and formist conceptual lenses. The philosophical frameworks, favored theories, and research methodologies (i.e., problem-solving heuristics) of each worldview differ markedly from those of the other worldviews.

In contrast, we can conceive of a problem-solving team that is locked into perceiving the world through only one worldview lens as being dogmatic and less effective when it comes to complex, creative problem solving. The effectiveness of this problem-solving team suffers because its entrenchment in a single worldview derives from the rust of dogmatism that locks up the central axle of the device, preventing the rotation of the conceptual lenses past the group's collective eye.

While Page's (2007, 2010) analyses of cognitive diversity apply to groups, we can conceive of the same dynamics applying to individuals. A single problem solver might experience the same creative opportunities offered by the rotating conceptual lenses in Fig. 4.1, and the same problems when the axle of his or her worldview apparatus locks up due to the rust of dogmatism. An individual who comes to understand the benefits deriving from perceiving the world through multiple worldview lenses can inject some creativity inducing cognitive diversity into his or her own mind.

4.3 The Dominance of the Mechanistic Worldview in the Minds of School Reformers

The four worldviews are ethically neutral (Pepper, 1942). The benefits or damage the worldviews can cause are determined by the use to which they are put. In most cases, benefits are derived when multiple worldviews are employed to create more comprehensive understanding of complex, multidimensional issues such as the nature of effective teaching and learning. Also in most cases, damage occurs when thinkers hold fast to a single worldview in efforts to grapple with complexity. Much of the severe damage caused by superficial school reformers appears to arise from their dogmatic, implicit adherence to a single worldview–mechanism.

An emphasis on machinelike structures and processes can be soothing to superficial reformers who lack the cognitive complexity to embrace ambiguity and do real creative work pertaining to the design and function of educational systems. When they reduce the whole education system to select micro-elements of cognition for use in the determination of objectives and accountability measures it does much to clear away clouds of ambiguity and to simplify their task. The mechanistic emphases on precision, detail, and linear causality align with and guide the development and application of the standardized tests required for their accountability systems. Finally, the mechanistic emphasis on objectivity cleanses them of responsibility for whatever damage they do to the educational system because they were simply being objective in their attempts to improve that system.

4.4 Using Worldview Perceptual Lenses to Escape Dogmatism and Generate Insights About School Reform

Because metaphor exerts such powerful implicit influence on our minds we can use it more purposefully to escape at least some forms of dogmatism. Based on the foregoing analyses, one obvious strategy for escaping such entrapment would be applying differing worldview metaphors to a difficult, complex problem or issue. In the case of dogmatic school reform, rotating the contextualist, organicist, and formist root metaphors over our field of vision can help us escape from the dominance of the mechanistic, human-as-machine, root metaphor that dominates the reformers' shortsighted, blinkered minds. For example, while the machine metaphor encourages reformers to force educators to narrow the curriculum so achievement can be measured precisely through psychometrics, the other metaphorical lenses can enable us to see alternative visions of achievement.

4.5 An Alternate View Through the Lens of Contextualism

Positioning the contextualist conceptual lens over our collective eye shown in Fig. 4.1 will focus our attention on aspects of education that the mechanistic root metaphor marginalizes because we will be viewing the education system through the conceptual framework highlighting the "ongoing event within its context generating the unpredictable emergence of novelty." The *ongoing event* of significance here is child and adolescent development and the *contexts* of primary significance are the socioeconomic systems of various nations and regions within nations. Instead of overemphasizing decontextualized knowledge and skills that are easy to capture through precise, mass-applied, standardized testing, the contextualist root metaphor will magnify the importance of context in teaching and learning. As a consequence, policymakers, citizens, and educators will become more aware of the ways in which socioeconomic inequality strongly influences educational achievement.

The "ongoing event within its context" dimension of the contextualist metaphor will encourage us to pay attention to the work of social epidemiologists Wilkinson and Pickett who generate extensive international comparisons of developed nations regarding their levels of inequality and social problems (see Pickett & Wilkinson, 2015a, 2015b; Wilkinson & Pickett, 2009, 2011). The nations with the highest levels of socioeconomic inequality manifest by far the most severe social problems including elevated levels of mental illness, drug and alcohol abuse, violence, incarceration rates, obesity, and teenage births, as well as poor life expectancy, low levels of trust, weak performance on mathematics and literacy educational achievement, and weak social mobility (the chances that a child eventually will surpass her/his parents' socioeconomic level).

The contextualist metaphor can encourage us to pay attention to the ways in which these enormous contextual problems faced by the deprived suppress their educational achievement while severely diminishing or precluding the discovery of aspirations and the discovery and development of talents related to those aspirations (see Ambrose, 2013; Biddle, 2014; Cookson, 2013; Cross & Borland, 2013; Duncan & Murnane, 2011; Fabricant & Fine, 2013; Lipman, 2004; Sacks, 2007). With the benefit of insights from the contextualist worldview, shortsighted reformers will find it more difficult to make excuses for their own lack of intellectual scope such as their ignorance of context in the "no excuses" admonitions they impose on teachers of impoverished children (see Sondel, 2015). American school reformers' ignorance of context is especially pronounced because the United States is the most unequal of the developed nations so it is the nation most severely plagued by the oppressive societal problems that accompany extreme inequality (Wilkinson & Pickett, 2009).

In addition, the "unpredictable emergence of novelty" emphasized by the contextualist worldview will magnify the importance of spontaneous, emergent creativity and learning. For example, it will make policymakers, citizens, and educators more aware that students are complex, adaptive systems navigating between excessive order and excessive chaos in their classroom settings and socioeconomic contexts and occasionally finding the creativity generating dynamic tension between chaos and order (see Ambrose, Sriraman, & Pierce, 2014).

4.6 Perceiving Additional Dimensions of Reform Through the Organicist Lens

While the hyper-mechanistic reformers tend to ignore the importance of exceptionally powerful contextual pressures on teaching and learning, they also ignore interconnected dimensions of the learner that extend beyond easily measurable cognitive processes. By flipping the organicist conceptual lens in front of our field of view we can perceive the intricate integration of subsystems within individuals and groups, the long-term sense of purpose that drives important creative achievement, and the senses of altruism and ethics that tie all of us together in a complex, turbulent world. Arguably, child and adolescent development that attends to these dimensions of human potential is at least as important as the learning of measurable academic content.

Cognitive processing of academic content is an important aspect of a good education but that processing can be much more dynamic and successful if it is augmented with other forms of development. Interestingly, some of the nations we most often put on a pedestal for their high levels of measurable academic achievement don't always employ the test-and-punish mentality of our superficial reformers. Finland, for example, has been very successful in international comparisons of student achievement but the educational system of that nation places strong emphases on the social and affective domains, independent thinking, the development of a sense of purpose, ethical sensitivity, altruism, and an egalitarian mindset (Tirri, 2011, 2016). In essence, this international exemplar of lofty academic achievement emphasizes the whole child, not just some easily measured decontextualized fragments of cognition.

Similarly, the Roeper school in Bloomfield Hills, Michigan values subject area content learning but does not prioritize it. Instead, the school emphasizes intrapersonal discovery of aspirations and talents, the development of a long-term sense of purpose, and ethical awareness (Ambrose, Sriraman, & Cross, 2013). Much of the reason for the school's remarkable success with this whole-child approach is the emphasis on bottom-up, democratic decision-making. Instead of imposing top-down, test-based sanctions to motivate teachers and students to work harder, the school enables students and teachers to make important decisions about their own development and the interconnected workings of the school. Of course, they are able to take this approach because they don't work within the public education system, which is encumbered with the onerous, imprudent demands of our current crop of misguided reformers.

In essence, when the organicist worldview lens cycles into our range of vision it clarifies the integration of subsystems within the whole child thereby expanding our sense of educational possibilities. Children immersed in an educational system that pays serious attention to the whole child can find opportunities to integrate their growing knowledge bases with the motivational fuel of positive affect and ethical awareness. This integration can initiate long-term developmental processes along the lines of those experienced by the big-C creators studied by Howard Gruber (1989, 1993, 1999). Such development involves a powerful and growing sense of purpose and the exploration and mastery of multiple, intertwining projects throughout the lifetime. Obviously, this kind of development represents a worthy educational pursuit if school reformers can escape their pernicious dogmatism long enough to appreciate it.

4.7 Understanding Troubling Similarities Through the Formist Lens

The smug, dogmatic certainty of many reformers largely derives from their unshakable belief in the hyper-mechanistic achievement measures they use for accountability purposes. The context-ignoring, whole-child-dismissing reductive precision they achieve by confining their vision to the mechanistic conceptual lens enables them to assume that their portrayal of educational reality tells the entire story about educational purpose and achievement. But when we flip the formist world view lens over our field of vision some helpful insights from far-flung disciplines come into play. These insights enable us to perceive the limitations of the reformers' confinement to the single mechanistic worldview lens because it makes available constructs such as market fundamentalism, the flight from reality in the human sciences, sterile certainty, and a troubling scientific illusion.

As with the repeating fractal patterns revealed by the transdisciplinary work of complexity theorists, the formist worldview allows us to cross disciplinary borders to discover patterns of similarity in the work of prominent political scientists, economists, and mathematicians, among others. First, the Nobel laureate economist Joseph Stiglitz (2010) argued that orthodox economics has been dominated for too long by *market fundamentalists* who believe that laissez-faire market dynamics unencumbered by government regulation will lead to the best possible economic outcomes. While illustrating the flaws in that logic, Stiglitz explained that he calls dogmatic economists market fundamentalists because their beliefs are resistant to new findings to the point where their thinking approximates the theological rigidity of radical religious fundamentalists. Positioning our similarity seeking formist perceptual lens over our field of vision enables us to perceive a similar phenomenon when it comes to the fundamentalist rigidity of school reformers who contend that unencumbered free-market dynamics such as school privatization can make education much more effective than it is under government control.

Three other prominent scholars provide additional formist patterns of similarity that can help us understand the limitations of holding firmly to the single mechanistic perspective on education. All three of these investigators call into question the extent to which academic research aligns with the reductive precision emphasized by the mechanistic worldview.

First, the well-known political scientist Ian Shapiro (2005) analyzed the conceptual frameworks dominating the law and economics paradigm in the social sciences and the rational choice model at its core. The notion that a *rational actor* makes clearly rational decisions based on comprehensive datasets for primarily selfish reasons doesn't align well with human nature, which includes considerable irrationality and healthy doses of unselfish, altruistic behavior. But the rational choice model works well as a framework for mechanistic model building and quantitative-empirical research; consequently, it retains a central place in the social sciences even though Shapiro calls the mismatch between the model and actual human nature the *flight from reality in the human sciences*.

Second, in his groundbreaking analysis of twenty-first-century capitalism, the leading economist Thomas Piketty (2014) argued that economics isn't nearly as scientifically precise as mainstream economists believe:

> I dislike the expression 'economic science,' which strikes me as terribly arrogant because it suggests that economics has attained a higher scientific status than the other social sciences.…For far too long economists have sought to define themselves in terms of their supposedly scientific methods. In fact, those methods rely on an immoderate use of mathematical models, which are frequently no more than an excuse for occupying the terrain and masking the vacuity of the content. (p. 573–575)

Piketty elaborated on this problem calling it a *scientific illusion*. He recommended that economists pay more attention to social, political, and cultural influences instead of relying excessively on reduction of the individual human being to a rational actor.

Third, the leading mathematician William Byers (2007, 2011) carried out extensive analyses of his own discipline and the natural sciences, arguing that theory and research in these fields, which are normally considered to be at the apex of the disciplinary hierarchy (see Simonton, 2004, 2009, 2012) are not nearly as logical, precise, and certain as many researchers and theorists assume. In actuality, there is considerable imprecision and uncertainty in the conceptual frameworks and central constructs of these fields and the scholars' craving of order makes them fall into a form of dogmatism that Byers calls *sterile certainty*.

By looking through the formist conceptual lens and perceiving the flight from reality in the human sciences, the scientific illusion of economics, and the sterile certainty that sometimes arises in mathematics and the natural sciences we are able to perceive parallels with the dogmatic, hyper-mechanistic conceptual frameworks that underpin school reform. If the social sciences and the natural sciences are prone to these forms of dogmatism we can safely assume that the much less rigorous conceptual underpinnings of school reformers' accountability systems likely are prone to severely damaging flights from reality, scientific illusion, and sterile certainty.

4.8 Visual Metaphor as an Unusual Dogmatism-Busting Tool

As is evident from exploration of education through the four worldview lenses in the previous subsections, school improvement is an immensely complex issue that goes far beyond the simplistic test-and-punish portrayals offered by most school reformers. Consequently, adequate understandings of creative, twenty-first-century teaching and learning require simplifications that don't entail too much loss of meaning. Convincing policymakers and citizens of the need for more comprehensive understanding of educational achievement also requires some creative scaffolding.

Complex but understandable graphic organizers can be helpful in this regard. Visual metaphors are particularly interesting graphic organizers. Depictions of the visual-metaphorical thought process come from the work of developmental psychologist Howard Gruber (1974, 1978) who carried out retrospective case studies on highly creative people. Gruber found that some prominent creators, notably Charles Darwin, constructed metaphorical images to clarify understandings of enormous amounts of data and difficult material. These *images of wide scope* synthesized a great deal of complex information in condensed form providing a basis for understanding the known and for launching more insightful searches into the unknown. Later, Cohen (1994) turned this process into a teaching strategy in which learners would *mode switch*, translating academic content from the way it originally was presented (e.g. text) into another form such as a visual-metaphorical sketch or painting.

The symbolism in the new piece of conceptual art would capture, simplify, and convey the content embedded in the verbal-symbolic work that was translated by the learner. An effective visual metaphor can synthesize a great deal of content and make it memorable for the learner, and possibly to her or his audience. The apparatus with the four worldview conceptual lenses in Fig. 4.1 is an example of a visual metaphor, in this case synthesizing a large amount of scholarship on the root-metaphorical worldviews by turning it into visual form.

I have created other two-dimensional and three-dimensional models to synthesize theory and research from multiple academic disciplines in order to capture the essence of complex phenomena while also making the transdisciplinary syntheses accessible to readers. For example, a two-dimensional model synthesizes scholarship from economics, history, political science, sociology, ethical philosophy, and gifted education to portray the dynamics of democratic growth and erosion in various societies (see Ambrose, 2005; Yamin & Ambrose, 2012). The model includes a double-ended ideological arrow signifying the dynamic tension between the right-wing tenets of individualism, economic freedom, and limited government and the left-wing tenets of community, distributive justice, and government regulation. A circle below the arrow conveys the dynamics of democratic growth in societies when widespread epistemic power (voter awareness) and prudent regulation are in place, as well as the erosion of democracy toward totalitarianism when either right-wing or left-wing ideological extremism takes hold. Implications of these socioeconomic phenomena are drawn for teachers and learners. The simplicity of the model conveys understanding of otherwise complex, obscure sociopolitical phenomena.

There is considerable metaphorical content in this model of democratic growth and erosion; consequently, it qualifies as a visual metaphor. Leading scholars of metaphor, Lakoff and Johnson (1980, 1999) described how spatial orientation is prominent in metaphorical thinking, especially the metaphorical notions that up is good and down is bad. The visual metaphor of democratic dynamics portrays growth of democracies as a vertical arrow going up through the middle of the model while democratic erosion is signified by movement down a slippery slope on either the left-wing or right-wing extremist edges of the model.

Another example of an interdisciplinary synthesizing visual metaphor portrays theory and research findings from ethical philosophy, history, political science, sociology, economics, and education in the form of a gigantic glass cube several thousand miles on a side, half filled with earthen material that has been shifted around to create mountains, valleys, and flat plains (see Ambrose, 2009). In the metaphor, the mass of humanity spreads out across the surface of the landscape inside the glass cube with those who have made enormous, positive moral impact on the world climbing up the peaks of benevolence and those who have done enormous evil descending into the valleys of malevolence. Billions of other individuals stand in or near the midrange neutral territory on the landscape because they have exerted little positive or negative moral impact on the world. The simple metaphorical model captures and conveys the essence of a large number of complex constructs including notions of universalist and particularist morality, relational altruism, quasi-altruism, and the work of the eminent philosopher Hannah Arendt, among many others. Without the visual metaphorical rendering, the interdisciplinary synthesis would require hundreds of pages of dense academic jargon that would be inaccessible to all but the most obsessive interdisciplinary scholars.

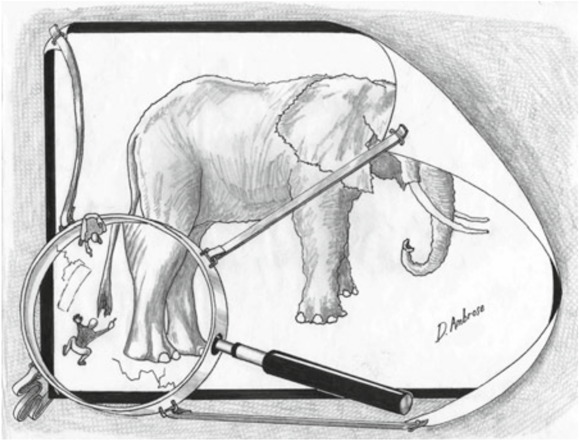

Fig. 4.2 Pachydermic Proof: A visual metaphor capturing and conveying the essence of paradigm shifts and dogmatism in academic disciplines–or the dogmatism of school reform initiatives (From Ambrose, 2016a)

This chapter concludes with one more visual metaphor, shown in Fig. 4.2. This image, inspired by the old Sufi parable of the blind men and the elephant, metaphorically symbolizes an academic discipline as a giant magnifying glass hovering over a photograph of an elephant, which represents all of the phenomena within the scope of the discipline.

Tiny researchers and theorists crawl around on the surface of the glass gaining a magnified, crystal-clear view of a small portion of the elephant so they assume that they are seeing the entire elephant. Meanwhile, the steel frame of the magnifying glass represents the epistemological and methodological conventions of the discipline. The rim pressures the scholars to conform to the favored thought paradigm of the day and they are strongly discouraged from looking beyond the rim where they might catch a glimpse of more of the elephant. Rubber bands of dogmatism attach the rim of the magnifying glass to the corners of the photograph of the elephant. Wherever the magnifying glass is positioned there likely will be some distortion or covering of the picture because at least one rubber band of dogmatism will pull up a corner of the picture and hide a portion of the elephant. So even when there is a paradigm shift, represented in this visual metaphor as a movement of the magnifying glass to make it hover over a different portion of the elephant, the scholars will be unable to perceive the entire picture of the elephant.

The only way to capture a comprehensive vision of the photograph is for the scholars to (a) realize they are limiting their vision by confining themselves to a narrow set of epistemological and methodological conventions, (b) cut the rubber bands of dogmatism, (c) set aside the magnifying glass, and (d) elevate themselves high above the picture to gain a panoramic vision that is detail-poor but rich in scope. After doing this they can return to their detail-focused, magnified view of a portion of the elephant, enriched by their newfound awareness of the entire picture.

While this visual metaphor was designed to capture and convey the essence of dogmatism in academic disciplines it also can be interpreted as a critique of the school reform agenda. For example, the entire picture of the elephant now becomes all of the possible dimensions of student growth including academic knowledge and skills, social and emotional development, creative and critical thinking, physical development, ethical awareness, and more. The sturdy, magnified rear leg represents the limited range of knowledge and skill captured by the reformers' primarily mechanistic accountability systems. The small individuals crawling around on the lens are the reformers. They peer through the glass gaining a magnified vision of what they think is the essence of learning and remain oblivious to the rest of the elephant that stretches beyond the rim of the glass. Their rubber bands of dogmatism are particularly strong and hide considerable portions of the big picture, thus making broader conceptions of learning far less accessible to policymakers, citizens, educational professionals, and students. Their narrow, intense focus on what's measurable through the lens of their reform magnifying glass makes it far less likely that students will enjoy school systems that are aligned with the complexity of the twenty-first century socioeconomic and cultural environment.

Much more detail can be added to this visual metaphor. Individuals and groups of educators, creativity researchers, and policymakers can play with it to make it capture more of the ideas that they think are important for the creation of a stronger educational system. For example, what might the cracks in the lens of the magnifying glass signify?

4.9 Concluding Thoughts

The root metaphorical worldviews implicitly operate on the mind so it is difficult to appreciate the ways in which they trap of us in dogmatic thought frameworks. Meanwhile, school reform initiatives are operated by, or at least heavily funded by, enormously affluent individuals and groups. Some of these leaders and funders are talented and accomplished in particular domains but have little knowledge of student learning or pedagogy. Other affluent, powerful leaders and funders simply inherited their privilege and have rather ordinary minds incapable of understanding the complexity of creative educational systems. Still others are predatory profiteers with little concern for the well-being of the millions of children who rely on thoughtful educational improvement. Making the worldviews more visible might be one way to reveal the limitations of current reform initiatives. In addition, using the rather unusual creative process of visual-metaphorical rendering to capture and simplify complex educational issues could help policymakers and the general public become more aware of the structure and dynamics of creative educational systems.

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Chapter 5
Creative Interpretations of Educational Contradictions

Mark A. Runco

Abstract This chapter explores the various relationships that exist between contradictions and creativity. The focus is education, with implications for both teachers and students. Contradictions are defined and contrasted with problems, disequilibria, and dilemmae. Product, place, personality, and process perspectives on creativity as also compared. The advantages of the process view are detailed and recommendations offered. These include (a) optimal challenges for authentic learning and the fulfillment of creative potentials, and (b) the recognition that contradictions and creativity both depend on interpretations.

5.1 Introduction

So much is being said these days about the need for creativity, no doubt because it is so clearly related to numerous forms of progress and success. Creativity is associated with adaptability, problem solving, flexibility, and even health. It underlies innovation as well as invention, entrepreneurship, various forms of discovery, and many mechanisms of advance (e.g., technological). Clearly fulfilled creative potentials would be of wide-ranging benefit.

One of the best ways to fulfill the creative potentials that are required for both creative performance and innovation is to insure that the educational system is supportive. And one way to insure the greatest impact is to identify the obstacles that plague efforts to support creativity in the classroom. Many of these obstacles reflect contradictions. Consider in this regard research showing that teachers typically value creativity but at the same time (and in opposition to their own values) they are unable to reward the divergent thinking, independence, autonomy, playfulness, and intrinsic motives of students. Fortunately there is also evidence that creative solutions are sometimes found when contradictions are embraced. In that sense the con-

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tradictions identified in this volume represent a very good first step towards creative solutions to some of the more pressing educational problems and obstacles.

This chapter pinpoints several of the contradictions that plague education. It also explores the meaning of a contradiction and compares contradictions with various related problematic situations (e.g., dilemmae, challenges, disequilibria, and just "problems"). This brings to light the different ways that a contradiction can be interpreted (e.g., as a problem, *or* as part of a larger, potentially fruitful creative process) and leads to several practical suggestions for how to view and use contradictions such that education can in fact operate to fulfill the creative potentials of students.

5.2 Where Are the Contradictions?

Not all problems facing education and obstacles to fulfilling creative potentials are contradictions. Yet many of the more difficult problems are difficult precisely because they are contradictions. One good first step is to evaluate the more pressing problems. Many of them are contradictions, and some are not, and some that do not seem to be contradictions are in fact, on closer inspection, contradictions. Consider, for example, the educational challenges identified not long ago by Runco (2013). He pointed first to a set of *common misunderstandings* about creativity. Runco cited the distinction of "Big C vs. little c" creativity as an example of one common misunderstanding. He described Big C and little c as a false dichotomy in the sense that little c creativity can become Big C creativity. Put differently, all Big C creativity starts with little c creativity. They are therefore connected, not distinct, and that connection is important to keep in mind, especially in education, where the intent is to fulfill potentials. Educators can assist little c creativity being transformed into Big C creativity, or at least into socially-recognized forms of creativity and creative achievement, but they will only do so if the connection rather than the distinction between Big C and little c creativity is appreciated.

The second educational challenge identified by Runco (2013) is related to but more specific than the first. This challenge is the result of the enduring myths about creativity. The *art bias* is one such myth, the crux being that creativity is always manifested in art, and thus only artistically talented students are creative. Clearly this flies in the face of data on the many other expressions of creativity, including linguistic, mathematical, bodily/kinesthetic, and interpersonal (Baer, 1998; Runco, 1987). If there is a contradiction here it is between the true nature of creativity (i.e., it can be expressed in various domains) and perceptions of creativity that see it only occurring in the arts.

The third challenge for education is a bit more general: The nature of creativity makes it difficult to support with systematic, programmatic methods. The originality that is a part of all creativity, for instance, cannot be predicted or guaranteed, so curriculum design is difficult. After all, how do you plan for originality? Most curricular plans are structured so the educator knows what will happen, and the educator can only know if it is predictable, which originality is not. Originality is by definition new and novel, so not easy to predict. That being said, there are several methods for insuring novelty. Pryor, Haag, and O'Reilly (1969), for example, described a training method that targets novelty. Simplifying a great deal, rewards are given to responses that have never been emitted before—that is, to novel behaviors. Holman, Goetz, and Baer (1977) also used training and confirmed that novelty can be trained.

The flip side of this, which is the fourth challenge, is that the traditional structure of education does not lend itself to easily supporting creativity. There is, for instance, usually one teacher and 20, 30, or even 40 students in any one class. Thus students need to work in groups, and this makes it difficult for educators to appreciate intrinsically motivated (i.e., idiosyncratic) ideation, and difficult to tolerate autonomous problem solving, playfulness, and incubation. The contradiction is easy to see: One the one hand, education is typically structured for groups, with a teacher directing all efforts, while students' creativity may flourish only with various forms of independence.

The last challenge identified by Runco (2013) reflects the lack of administrative support for creativity. Most disturbing here is duplicity by decision makers who claim to support creativity but, at the same time, undermine creativity with micromanagement when autonomy is instead required. This may take the form of deciding how teachers and students should be creative and by carefully evaluating (and thus inhibiting) all educational efforts. It is analogous to business where the bottom line is all-important, and the process, though important for creative thinking, is relegated. That may not be an analogy after all: Money has become increasingly involved with education, as if education was a business. Administrators are indeed watching the bottom line.

Admittedly, there is a risk when investing in creativity (Rubenson & Runco, 1992, 1995). A person takes a risk whenever he or she shares an original idea. That is because original ideas are by definition unconventional, and this means that other people may not like or understand them. As is evidenced by the increased accountability and standardization in so many schools, administrators tend to dislike such risks. Note here the contradiction between standardization and individuality, between accountability and exploration, and between the agenda of many contemporary educational settings that the requirements of creativity.

5.3 Product vs. Process

One way of looking at the situation described above draws from the 4P framework. This was originally proposed by Rhodes (1961) after he had examined what was at that time a representative sample of the published creativity research. He saw four strands in that research, including the creative Person, creative Process, creative Product, and creative Press. The last of these refers to environmental *press*ures on behavior. The more recent descriptions of the 4Ps often use the label Place rather than Press. This is slightly unfortunate because there is an advantage to the idea of

Press. That is because so-called Press factors can be of two sorts: one has an influence on behavior only if it is recognized by the individual, and the other needs no recognition. This is an important point because it brings individual differences into account. Too often environmental influences on behavior are assumed to have an impact when in fact the impact depends on the individual. What is significant for some people may be unimportant and even unnoticed by others. The impact of stressors (e.g., vacations, promotions, new family members) shows this clearly, but it is just as true of potential influences on creativity. In both cases the interpretation by the individual is more important than the environmental factor itself. In the classroom there may very well be students with strong ego-strength (Runco, 2003) who express their creative ideas regardless of the reactions by their peers or even the teacher, but other students are likely to be sensitive to interpersonal judgments and expectations. These two groups of hypothetical students are likely to interpret classroom supports and peer reactions in very different ways, as will be apparent in their unconventional and creative tendencies.

The 4P approach has been modified several times. Simonton (1991) added Persuasion to the list, the idea being that creative ideas and creative people change the way others think. This is a very useful addition to the 4P framework, at least when creativity is defined in terms of social recognition or when socially recognized creative achievement is the primary concern (cf. Runco, 2009). Another modification was presented by Runco (2007). He revamped the entire 4P framework such that it became a hierarchy. This has *Creative Performance* as one super-category and *Creative Potential* as the only other super-category. Creative products, creative achievement, creative activity, creative accomplishment, and all manifest expressions of unambiguously creative behavior are subsumed under the former. Creative personality, the creative process, and creative places are subsumed under the latter. This follows logically from the fact that personality, process, and place aspects of creativity do not necessarily lead to manifest performances. A person could very well have many of the core characteristics of the creative personality (e.g., openness, autonomy, intrinsic motivation, flexibility, playfulness), for example, and not actually put them to use and not actually produce any creative result. Personality traits are in that light indicative of creative potential. Recall also what was said above about Press or Place influences. They may or may not lead to actual creative behavior. Like Personality, Place influences do not guarantee actual performance but instead are indicative of potential creativity.

This hierarchical framework can be applied to the challenges listed above and applied specifically to educational contradictions. Simplifying some, educational considerations too often emphasize products and de-emphasize process and other aspects of creative potential. Similarly, traditional education too often values certain domains and expressions of performance (and awards high grades to them) when original ideas and thinking may be more indicative of the skills and aptitudes that will allow students to succeed in the long run, outside of school. This claim about long-term success follows from research showing that creative skills, including the capacity for divergent thinking, are correlated with activities and achievements, in various domains, that occur in the natural environment (Plucker, 1999; Runco, Millar, Acar, & Cramond, 2011; Wallach & Wing, 1969). Runco et al., for example, described a longitudinal study, with creativity data collected in the late 1950s still correlated with certain expressions of creativity even 50 years later!

Certainly, educational settings vary quite a bit and much of what has been said above applies only to extreme cases and a highly traditional classroom and school. The variation among educational settings is especially obvious if a cross cultural perspective is taken (Kim, 2005; Rudowicz & Yue, 2002), which means that the contradictions just noted do not apply universally. Still, the contradictions are concerns even if they are not universal. Not all schools emphasize products and the conventional side of the various contradictions, and those that do not may still be supporting creative potentials adequately. Yet the fact remains that it is more difficult to support creativity adequately when there is an emphasis on products and conventional performances.

5.4 Utilizing the Contradictions

So far I have described the situation but said little about what can be done. It is possible that merely identifying the problems that result from the challenges will show the way to progress. But there are specific and concrete recommendations for education that actually use the contradictions to find solutions and thus are especially likely to lead to progress and the fulfillment of creative potentials.

Consider the situation where a curriculum emphasizes the memorization of facts. This is can be contrasted with education that provides opportunities for the production of new ideas. That distinction and possible contradiction has been recognized for many years. Wertheimer (1945), for example, distinguished between *reproductive thought*, which results from the memorization of presented information, and *productive thought*, which results from creative thinking and the generation of new ideas. He was quite clear that education that requires repetition is likely to lead only to reproductive thinking and is likely to preclude creative thinking. Given the era in which he worked it is not surprising that he pointed to *conditioning* to explain repetition in the classroom. He also argued that a student does not really understand if there is only repetition, obedience, and reproductive thinking. Given his background in Gestalt psychology, it is also not surprising that he felt that insight played a role in productive and creative thinking. Insight can contribute to creative problem solving (Epstein, 1990; Gruber, 1981) though it is not the only way to find creative solutions.

Piaget (1976) held a very similar view of education and creativity. He described how teachers must present material such that learning involves authentic understanding rather than mere reproduction and memorization. For Piaget authentic learning is possible if students are optimally challenged. When this occurs, students are the most likely to *assimilate* and then *accommodate*, the end result being the new cognitive structures that are indicative of authentic understanding. As Piaget put it, “to understand is to invent.” Each student must invent meaning for him- or herself. Without this invention, information might be memorized but is not truly understood. It will not be useful outside of the classroom, nor generalize to the natural environment.

Some time ago I extended this line of thought and concluded that this exact same process—authentic learning–is involved in all creativity. That is what I meant above by suggesting that there is a way to deal with the contradiction between memorization and creative thinking. When education emphasizes memorization, the goal *is* understanding, but as Piaget proposed, that goal is actually better attained when students are given the opportunity for authentic learning. With that in mind, recall Piaget's claim that "to understand is to invent." This brings creativity into the equation because authentic learning is itself a creative process! As I put it elsewhere, "to understand is to create." What is created is meaning and understanding. This process has been called *personal creativity* because it must occur within the individual. One person cannot provide another with authentic understanding. Such understanding must be invented or created by oneself. It is a personal process. It is entirely germane to the apparent contradiction between learning and creativity (and productive thinking) because it ties them together. Authentic understanding depends on creative thinking.

Personal creativity and the construction of new meaning and understanding may seem to play a small role in many creative accomplishments, and in particular play a small role in socially recognized creative performances, but as a matter of fact all socially recognized creative acts are best understood as more than just creative. They start with an original interpretation (i.e., the result of the personally creative process described just above) but the resulting new idea or insight is then shared and judged to be creative by others. In the theory of personal creativity, only the first part of that process–the construction of an original interpretation–is creative. The sharing and judging occur after the fact, and for the sake of parsimony, the separation between social recognition and creativity per se should be recognized.

This is only one view of the creative process; others include both the insight of the individual as well as the judgment by others as parts of creativity. Csikszentmihalyi's (1990) systems theory is, for example, quite clear about the social requirements. He described the process as beginning with the individual, who has an idea or breakthrough that influences experts within a field, and if they eventually use the same idea, the entire domain is changed. If the domain is changed, novices and students entering the domain will see that idea as a given, and the process may begin all over again. That process probably does describe famous creative breakthroughs, but it conflates creativity (bringing something new into being) with social impact, reputation, and fame (Runco, 1995). The theory of personal creativity is, in that light, more parsimonious than systems theory and more parsimonious than any theory of creativity that includes social recognition and judgment as required for creativity.

5.5 Back to the Classroom

In addition to being less than parsimonious, theories of creativity that include social recognition and persuasion do not apply well to the classroom. Young students can be enormously creative, but it may not be creativity that is noticed by experts nor change the way that others think. Personal creativity, on the other hand, defined in terms of the construction of original interpretations and understandings, can be seen (and encouraged) in young students. As a matter of fact the idea that creativity requires social recognition is likely to be detrimental to education for creativity. That is because students too often over-emphasize peer pressure and the opinions of others. At around age 8 or 10, they become highly conventional. They move out of a preconventional stage where their thinking does not recognize nor process social pressures. Students in the conventional stage give great weight to peers and expectations and fitting in with the crowd. When this happens, their creativity suffers. Such conventional children become less original and more conventional. If education emphasizes socially recognized creativity and conventionality, a drop in originality and self-expression is likely.

That it is not an either/or situation. Realistically students should respect what others think but also be able to think for themselves. This is exactly how *post-conventional thinking* is defined (Runco & Charles, 1997). Along the same lines students should both memorize information and construct their own interpretations. They should practice convergent thinking as well as divergent thinking. They should sometimes conform, but other times rebel. The goal of education is to insure that students are adaptable and live healthy, productive lives. Creative skill will go a long way, but again, adaptable, healthy, and productive lives do not only require creative thinking. Facts are good to have, conventions sometimes enormously useful.

This is one reason to be weary of contradictions: they may imply simplicity that is unrealistic. Very often in life decisions depend on context. Life itself is a process. What works some of the time may not be best other times. Divergent thinking may be good for creative problem solving, but sometimes students need to be convergent. Students should be allowed to follow intrinsic interests when possible, given that these seem to lead most easily to self-expression and original ideation, but students should also recognize when it is time to earn a high grade or reproduce memorized material. Note that the Process view, mentioned earlier as part of 4P theory, is again useful. It allows appreciation of both sides of many apparent contradictions. By taking a process view, the different sides of each contradiction can all be respected, each at the right time.

5.6 Utilizing Contradictions

The process view just described suggests that some contradictions may not actually be problematic because one side (e.g., divergent thinking, intrinsic motivation, or going contrarianism) may be realistic at one point in time while the contrary side (e.g., convergent thinking, extrinsic motivation, or conventionality) might be realistic at a later point. Another way of approaching contradictions is suggested by studies of creative individuals who have utilized contradictions for their work. Barron (1963) and Runco (1994) each described how creative individuals often prefer situations that contain contradictions and conflict. As a matter of fact this is probably related to what has been labeled the *paradoxical personality* (Csikszentmihalyi, 1996; MacKinnon, 1965). The paradoxical personality is so-named because it manifests itself in paradoxical ways, being both introverted and extraverted, masculine but also feminine, open but also focused. Very likely, creators who display the paradoxical personality are expressing themselves in an authentic manner. Consider masculinity and femininity: Very frequently individuals behave in accordance with one or the other polarity because they feel that is what is expected. It is, in that light, a kind of conformity—conformity to social norms and pressures. Individuals who are sometimes masculine and sometimes feminine, on the other hand, might very well be following their true feelings rather than conforming. They are self-expressive rather than conforming to stereotypes, expectation, and convention. No wonder psychological androgeny, which is defined as being open to both masculinity and femininity, is correlated with creativity (Harrington & Anderson, 1981). There is of course a lesson there for educators (and parents): children should be encouraged to express their authentic selves rather than always conforming to what is expected.

There is other research, in addition to that focused on paradoxical personalities, that also indicates that creative thinking can utilize contradictions. Rothenberg (1999), for example, went into some detail about the *Janusian thinking* that he felt could explained many creative breakthroughs, including Existentialism (the finite and infinite coming together) and the Complementarity of Physics (with light having both wave and particle tendencies). The name Janusian was taken from the Roman god of doorways who was able to look outward and inward at the same time. It exemplifies the capacity to utilize contradictions, at least when the creator uses two seemingly contradictory inputs, simultaneously.

Acar and Runco (2014, 2015) also examined the role of contradictions in creative thinking. Their starting point was to question the theory of divergent thinking. In particular, they argued that actual or *literal divergence* was not being measured by existing tests, even though they were labeled tests of divergent thinking. Acar and Runco developed a method to get at literally divergent thinking. This is thinking that does in fact diverge. Of most relevance was Acar and Runco's identifying 13 bipolar conceptual categories (e.g., immoral ideas vs. moral ideas, feasible solutions vs. unrealistic solutions). They then examined ideas produced by a group of examinees and found that some people were indeed able to include contradictions (i.e., opposing conceptual categories) in their thinking. This capacity was correlated with an external measure of originality.

It is possible that many students have the capacity to think about contradictions but do not do so. They may recognize that there is a contradiction or paradox—and decide that there is no need to invest any more time or thought because, in their eyes, the contradiction holds no promise. It is a dead end. This is, however, just one interpretation of a contradiction, and there are others. Indeed, it is useful to consider the options for how someone might respond to a contradiction. One option, just described, applies when the person interprets the contradiction as a block or insurmountable hurtle and thinks no further about it. A second option is to ignore or deny the contradiction. This is patently unrealistic. If there is a contradiction, there is a contradiction. It should be acknowledged rather than ignored. If it is daytime, but the sun not visible, it is unrealistic to stick with "the sun is nowhere to be seen so it must be nighttime." Of course, residents of the northern climes and others who have experience with the so-called midnight sun would have an advantage when it comes to thinking about nighttime and the sun, as would people who have seen a total eclipse of the sun.

A third option is almost as unrealistic. Here the person, when faced with a contradiction, emphasizes one side of the contradiction over the other, so the contradiction is diminished. The situation becomes one-sided. This may not sound like something that really occurs, but it is not far from the reactions to cognitive dissonance that have been demonstrated many times over. A fourth option is to integrate or conflate the two sides of the contradiction so there is no longer a contradiction but instead one blended interpretation. Instead of red and blue, we have purple–an all-new result. Better yet, since red and blue are not opposites, this option can explained as dialectical, with a thesis, and an antithesis, but then a synthesis, which is literally a blend of the thesis and antithesis. The thesis is gone, as is the antithesis. All that remains is the synthesis.

The last option is the most difficult–and the most creative. This option accepts the contradiction as contradiction rather than ignoring or resolving it. Yes, light behaves as if it is made up of waves, and yes it behaves as if it is made up of particles, and yes those are quite different, with continuous energy or quanta, but they both accurately describe light, even if taken individually each precludes the other. This option (accepting two contradictory conditions as both true, even though they are in opposition) is possible because creative thinking is possible.

It may help if we shift perspectives such that we think like humans instead of thinking like scientists. I say that because scientists are trained to isolate the constituents of life and see individual variables. These may be tested in experiments with manipulations of independent variables and measurement of dependent variables. But reality is actually much more chaotic–and contradictory. Perhaps you have loved someone, such as a family member, but once in a while could not stand them. Could the words love and hate both apply to this kind of relationship? Even though contradictory?

5.7 Final Thoughts

This chapter opened by reviewing various challenges that face educators who wish to support creativity in the classroom. These were introduced as challenges and not necessarily contradictions. That difference is clear if "contradiction" is itself defined. A contradiction can be operationalized for the educational context as a set of goals that are in opposition to one another. Thus a teacher may have "fulfilling students' creative potential" as a goal, but at the same time need to work with a group of students –the entire class–and thus need to build a curriculum that emphasizes extrinsic rather than intrinsic motivation, conventions rather than originality, and so on. In this sense the common situation, which seems at first blush to be a contradiction, with educators valuing creativity but not tolerating autonomy, intrinsic interests, and divergent thinking, is not so much a contradiction in their thinking as it is a situation where there are opposing pressures and demands placed on the teacher.

The need for divergent thinking (and thus originality) in students' work may be closer to an actual contradiction because there is also a need for convergent thinking, and yet thinking is either divergent or convergent (cf Eysenck, 2003). Here the idea of a process is again helpful because students can practice divergent thinking some of the time, and at other times practice convergent thinking. If creativity is viewed as a process, it is possible to target the components of creativity in the classroom, even if they are contradictory. This idea is entirely consistent with theories of creativity as a process, as well as theories of creativity that emphasize stages and phases. Basadur (1995) proposed almost exactly this, with stages of divergence and then stages of convergence, though he was thinking mostly of the industrial organization setting rather than the educational setting.

Getting back to the definition itself, contradictions imply an opposition of goals or ideas. Contradictions can be viewed as a particular kind of challenge or problem. The concept of a *problem* is quite general. A problem is said to occur whenever there is a goal but an obstacle to that goal. While on the topic of definitions it is also useful to define a few other related terms. That is because some situations and concepts that are related to *contradiction* are associated with the creative process. This was apparent in the discussion of the *paradoxical personality*, and other similar concepts lead directly to practical suggestions for educators who wish to support creative potentials. Consider, for example, Piaget's (1976) concept of *disequilibrium*. This occurs when a child's cognitive structures are not adequate for the understanding of some new situation. When disequilibrium occurs the child is intrinsically motivated to assimilate and accommodate, and thus adapt to the situation and build new structures that allow understanding. This is all quite relevant because the process is initiated and motivated by disequilibrium–a kind of challenge. Piaget's ideas are also relevant because, as described earlier, "to understand is to invent."

Even closer to contradiction is Kohlberg's (1987) theory of reasoning. It is closer because Kohlberg focused on *dilemmae* as initiating and motivating development. A dilemma is a problem created by two opposing options. Hence the prefix, "di," which means two. Kohlberg formulated his theory by examining moral dilemma, such as might occur if a child feels the need to stick with a promise made to a friend but at the same time feels that he or she should admit something about that friend to the parents or teachers. Rosenblatt and Winner (1988) and Runco and Charles (1997) applied Kohlberg's ideas to creativity. This was a logical thing to do because moral reasoning develops through stages where thinking is Preconventional, Conventional, and (given the right experiences), Post conventional–and creativity, like morality, involves conventions. Simply put, if an idea is highly conventional, it is unlikely to be original and is thus not creative. All creative things require some sort of originality (Runco & Jaeger, 2012) though there is more to it than just originality.

Kohlberg's approach may be directly applicable to the present discussion because he described the benefits of experiencing dilemmae, and the benefits may apply to students experiencing contradictions as well. This is not to say that students should be bombarded with contradictions! They should not be bombarded with dilemmae either, but they should also not be overly protected from dilemmae nor contradictions. Instead they should be taught the value of contradictions and taught how to deal with them—how to utilize them. As a matter of fact this was one conclusion from a review of the research on tension and conflict as related to creativity: that dealing with tension and conflict can enhance a person's adaptability (Runco, 1994). It can also increase confidence and ego-strength. Barron (1963) went as far as to suggest that high level creators seek out situations with tension and conflict because they have had experiences that taught them that creative insights often result from the resolution of conflict. Kohlberg's view was that children will develop higher level thinking if they have experience with dilemmae, and if Rosenblatt and Winner (1988) and Runco and Charles (1997) were correct about creativity being a post-conventional capacity, then experience with dilemmae should contribute to more mature creative thinking skills. It is not much of a leap to apply this reasoning to contradictions since they are so closely related to dilemmae and disequilibrium.

This chapter offers a number of practical suggestions. These should benefit educators, but as should be quite clear at this point, there is much for students as well. Students can, for instance, be taught that the creative use of contradictions is not in the elimination of the contradiction but in the creative interpretation of the contradiction. They may also need to learn to tolerate contradictions rather than always avoiding or denying them. Students should not view contradictions are problems but as opportunities instead. More generally, they should recognize that what is most important is their own interpretation of the contradiction. This will give them control over the contradiction (i.e., they can reinterpret it as an opportunity) and provide them with practice at creative thinking, at least if the theory outlined herein is correct, with the construction of original effective interpretations the basis for personal creativity. This in turn the starting point for all creativity, even social recognized creativity. Educators would benefit if they support the personal creativity of their students, including the process of creative re-interpretation, and if they themselves model personal creativity when faced with contradictions in the educational setting.

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Chapter 6
Subordinated and Rebellious Creativity at School

Maciej Karwowski

Abstract Schools have poor reputation among creativity researchers. Teachers' biases and implicit theories, disruptive behaviors among creative students, and the equivocal pattern of the relationship between creativity and school achievement all contribute to this fact. This chapter presents a new typological model of creativity and demonstrate how this model and its categories may be useful in understanding different, often contradictory, findings present in the creative education literature.

6.1 Introduction

It goes without saying that schools have poor reputation among creativity researchers. Indeed, creative students often face problems when at school. Teachers' biases and implicit theories (Westby & Dawson, 1995), disruptive behaviors among creative students (Butcher & Niec, 2005), and the equivocal pattern of the relationship between creativity and school achievement (Gralewski & Karwowski, 2012) all contribute to this fact. Associations between creativity and education are often contradictory, and ideology and common sense usually get more attention than the more balanced research findings (Hanson, 2015).

In this chapter, I sketch a new typological model of creativity and demonstrate how this model and its categories may be useful in understanding different, often contradictory, findings present in the creative education literature. Further on, I mainly focus on two categories of this model, i.e. subordinated and rebellious creativity. This very basic distinction may allow for explanation of the observed differences and a better understanding of mixed findings obtained in previous studies.

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How is creativity most often conceptualized by scholars? The answer is obvious: "It depends." It depends on theoretical and epistemological orientation (Glăveanu, 2014; Hanson, 2015), egalitarian versus eminent perception of creativity (Simonton, 2000), and countless other factors. On the other hand, creativity researchers usually analyze creativity using what I call "level-and-variable-centered approaches." By level-centered approach I mean those theoretical perspectives that distinguish several hierarchically organized levels of creativity – from little-c to Big-C (e.g., Kaufman & Beghetto, 2009). By variable-centered perspectives I mean such multivariate approaches (Lubart & Guignard, 2004) that serve to describe and characterize creative people by focusing on their broad cognitive, personality, and conative characteristics (Barbot, Besançon, & Lubart, 2011). Applied to different levels of creativity, this approach allows for a rich and multifaceted description of more and less creative people in terms of their intelligence (Jauk, Benedek, Dunst, & Neubauer, 2013), special abilities (Silvia, Beaty, & Nusbaum, 2013), personality characteristics (Feist, 1998), or creative self-beliefs (Karwowski & Lebuda, 2016). Although it has been dominant in creativity research since the famous Guilford's (1950) address, this approach rarely translates into a more person-centered analysis.

What I propose and develop in this chapter is a follow-up to a person-centered creativity model introduced in greater detail elsewhere (Karwowski, 2010a; Karwowski & Jankowska, in press). This model draws on but also goes beyond the level-centered and the variable-centered approaches. It conceptualizes creativity in a typological and profile-centered rather than variable-centered way. As I apply this model mainly to creative potential and pay special attention to the functioning of different creative types in school settings, before describing the main characteristics of this model let me provide some context and discuss the main level- and variable-centered approaches relevant for further analysis.

6.2 The Level- and Variable-Centered Approaches

6.2.1 The Level-Centered Approach

One of the most common characteristics of creativity literature is its split between different levels of creativity – scholars are usually either interested in creative potential or in more or less visible aspects of creative activity and achievement. Rarely are these two aspects analyzed together (Glăveanu, 2015a; Simonton, 2000), and this dichotomy is even perceived as one of the most harmful phenomena for the whole creativity research (Glăveanu, 2015a), as it may inhibit new theorizing and empirical studies that could connect potential and achievement. Although early theories of creativity have already proposed the distinction between potential and achievement, or activity- and talent-based creativity (Maslow, 1967), the more complex approaches to the analysis of creativity levels are quite recent and at least two of them, developed in parallel, are relevant for further analyses. The first, called the "four-c" theory of creativity (Beghetto & Kaufman, 2007; Kaufman & Beghetto, 2009), draws a path from mini-c creativity to Big-C creativity highlighting the specificities of each of the four different levels of creativity – mini-c, little-c, Pro-c and Big-C, as well as the relationships between them and the possible ways of changing each lower level of creativity into a higher one. This model goes beyond the dichotomy of little-c versus Big-C creativity (see Karwowski, 2009), especially by adding mini-c creativity, which is integrated in the learning processes (Beghetto, 2016; Beghetto & Kaufman, 2007), and Pro-c creativity, connected with professional development and expertise in the field. Mini-c creativity is intrinsically motivated, works at both domain-general and domain-specific levels, and is studied microgenetically. Little-c creativity is closely related to small-level-real-life innovations: usually solving problems important for the individual, but not for the whole field of study. Like mini-c, it is usually intrinsically driven, and its level may be assessed using self-, teacher or peer ratings or divergent thinking tests.

Pro-c creativity is clearly domain-specific, with a higher role played by extrinsic motivation (though it is still to some extent intrinsically motivated), and describes the kind of creativity that is connected with some level of professional development, beyond the little-c, but below the Big-C level, which is clearly domain-specific and associated with great innovations and discoveries that change human lives. Kaufman's and Beghetto's (2009) model offers several testable hypotheses on the paths of creativity development and transition between levels. Importantly, this model also finds support in laypeople's implicit theories of creativity, as several studies have demonstrated that people are able to differentiate not only between little-and-Big-C creativity (Karwowski, 2009), but also between the more nuanced levels of mini-c and little-c or Pro-C and Big-C (Beghetto & Kaufman, 2015; Kaufman & Beghetto, 2013). This effect replicates cross-culturally as well (Puente-Diaz, Maier, Brem, & Cavazos-Arroyo, 2015).

The second, less known model, was proposed by Nęcka (2001; see also Nęcka, Grohman, & Słabosz, 2006). It involves four levels of creativity as well, namely: fluid, crystallized, mature, and eminent creativity. Fluid creativity is associated with divergent thinking, originality of ideas, and several personality traits, mainly openness to experience and curiosity. It is assumed to be normally distributed and to be domain-general rather than domain-specific. The second level in Nęcka's hierarchy is crystallized creativity – a clearly more domain-specific one. The distribution of crystallized creativity in the population is right-skewed. The only difference between mature and eminent creativity lies in the social evaluation of the product. Therefore, it is difficult to decide which creator is on the mature level and which is on the eminent creativity level – the distinction is usually quite intuitive and based either on social recognition (e.g., Nobel prizes), or on its influence on paradigms (the creators who change paradigms are perceived as more eminent than those who improve them) or other, less objective criteria (Kasof, 1995).

In sum, Kaufman and Beghetto as well as Nęcka offer general theoretical models that better organize creativity studies and explain the rarely analyzed path from mini-c to Big-C (or from fluid to eminent, to use Nęcka's words) creativity (Plucker, 1999), or from Pro-c or crystallized creativity to Big-C / eminent creativity (Feist & Barron, 2003). Still, these models work as conceptual or heuristic schemata that need to be filled with detailed characteristics and processes observed on each level of creativity. Depending on scholars' theoretical orientation, such analysis may focus mainly on the inter- and intra-individual characteristics of people on different levels of creativity (see e.g., Furnham, Batey, Booth, Patel, & Lozinskaya, 2011 for an individual differences approach), processes relevant to each type of creativity (see e.g., Finke, Ward, & Smith, 1992; Silvia & Beaty, 2012 for cognitive approach), or social conditions crucial for each type of creativity (see e.g., Glăveanu, 2015b for social approach). Thus, we can apply the more classic person-process-product-place approach (four-P; Rhodes, 1962) or the more contemporary actor-action-artifact-audience-affordances approach (five A; Glăveanu, 2013) to deepen our understanding of each creativity level. Usually, such deepening was done from a person perspective (or actor perspective, to use Glăveanu's term) and focused on the characteristics that were considered specific for creative people.

Consequently, creativity scholars highlighted the role of a broad set of creative abilities, including divergent thinking (Baer, 2014; Runco & Acar, 2012), creative imagination (Dziedziewicz & Karwowski, 2015; Jankowska & Karwowski, 2015), the ability to produce metaphors (Silvia & Beaty, 2012), or making unusual and remote associations (Gupta, Jang, Mednick, & Huber, 2012). Such abilities are usually perceived as a *conditio sine qua non* of each level of creativity and the crucial element of the creative potential. Below, I argue that while creative ability indeed seems crucial for creative actors' characteristics, other personality traits, especially openness and independence, are equally as relevant while looking for different configurations of the creative mind and creative behavior.

6.2.2 The Variable-Centered Approach

Creative Ability and Openness Sometimes (Runco, 2015) creative potential is equated with creative ability. However, arguments presented elsewhere (Karwowski, 2015), call for a more inclusive definition of creative potential that would include non-cognitive (e.g., personality) factors that play an important role in activating, maintaining, and finalizing creative activity. The personality trait theorized as crucial for creativity (sometimes even equaled with creative potential; see Martindale, 1989) is openness or openness / intellect (DeYoung, Quilty, Peterson, & Gray, 2014). Meta-analyses (Feist, 1998; Karwowski & Lebuda, 2016) and an enormous number of empirical studies demonstrate that openness is consistently related to different levels and aspects of creativity – i.e., divergent thinking (Beaty & Silvia, 2012), analogies (Liang, Hsu, & Chang, 2013), metaphors (Silvia & Beaty, 2012), problem solving (D'Zurilla, Maydeu-Olivares, & Gallardo-Pujol, 2011), creative achievement in general (Carson, Peterson, & Higgins, 2005), as well as the likelihood of engagement in creative activity (Beaty, Nusbaum, & Silvia, 2014; Karwowski & Lebuda, in press; Silvia et al., 2014).

Importantly, various aspects and facets of openness are differently related to various domains of creativity – while openness tends to predict creative ability, intellect predicts intelligence (Nusbaum & Silvia, 2011). Recent studies also show that while artistic creative achievement is predicted by openness, creative achievement in science is predicted by intellect rather than openness (Kaufman et al., 2015). However, the take-home message is quite straightforward – creativity without openness is hardly possible, and creative individuals (including creative students) are, by definition, more open than the less creative ones. But is creativity really impossible without openness? I will get back to this issue in the last part of this chapter.

Nonconformity/Independence Assuming that at least above-average creative ability and a high level of openness / intellect characterize creative people on each level of creativity, (being relevant for someone on the fluid creativity level as well as for the eminent creator) the important question may read: what else is there to creativity? What are other, maybe less obvious, characteristics of creative individuals? What personality or conative factors drive people to creative activity? The research to date proposes several such characteristics: above-average intelligence (Karwowski & Gralewski, 2013), intrinsic motivation (Amabile, 1996), high level of self-confidence (Karwowski, 2011), or specific thinking styles (O'Hara & Sternberg, 2001). However, there are good reasons to believe that the third broad area of personality characteristics relevant for an individual's creativity is related to his or her nonconformity and independence, or – even more broadly – those personality characteristics that are related to the psychoticism. Unlike creative ability and openness, this line of analysis still remains controversial, so I devote more space to the discussion of these relationships.

Mass culture provides collective imagination with many reasons to believe that the distance between creativity and rebellion that sometimes turning into aggression is not as large as it may seem. The established stereotype of a mad creator, a misunderstood genius unadjusted to the environment and frequently reacting to others with aggression is present in popular books (an example being Lisbeth Salander in Stieg Larsson's *Millennium* trilogy) as well as in movies (Will Hunting in Gus van Sant's *Good Will Hunting* or Alex de Large in Stanley Kubrick's *A Clockwork Orange* based on Anthony Burgess's prose), or in the biographies of eminent creators – frequently aggressive or self-aggressive (for instance, Vincent Van Gogh). However, anecdotal examples rarely make it possible to understand the mechanisms and processes underlying the possible relations between these phenomena.

One of the first studies conducted at the Institute of Personality Assessment and Research (Cattell & Drevdahl, 1955) that sought personality characteristics in a survey of three groups of creators (writers, artists, and science-fiction writers), found that all the three groups scored below the norm on Factor A (cyclothymia-schizothymia) measured with the use of Cattell's Sixteen Personality Factor Questionnaire (16 PF) describing warmth, social ability, and adaptability. A study of eminently creative architects (MacKinnon, 1965) showed that, compared to their less creative colleagues, these people were characterized by higher aggressiveness, dominativeness, and need for autonomy as well as worse social adjustment. These findings were confirmed in a subsequent study (Hall & MacKinnon, 1969), where it was found that the most creative architects scored low on social adjustment and conformism. A comparison of film artists with a control group (Domino, 1974) showed that the former exhibit a higher need for achievement than the population of non-artists.

It is to Eysenck (1993, 1995) and to the emphasis he placed on the importance of psychoticism that we owe what is probably the most complex theory of personality determinants, which is also the most useful one for the reflections presented in this chapter. In Eysenck's theory, differentiation of the intensity of creativity understood as a trait is due to differences in psychoticism – a complex personality dimension loaded by specific traits such as aggression, assertiveness, antisociality, egocentrism, lack of empathy, or impulsiveness (Eysenck, 1993, p. 155). The author infers these relations from his theory of personality as well as from a critical review of literature on the relations between creativity and psychopathology stating that when mental health and illness are treated not as separate nominal categories but as extremes of a continuum, it is easy to notice that a certain level of psychopathology is indeed observed in creators, though it rarely amounts to a disease entity (see also Simonton, 2016). According to Eysenck, creative individuals have a higher level of psychoticism that, in some cases, may lead to psychoses, but its above-average intensity can also be a stimulator of creative activities. What creators have in common with people who experience psychosis is a characteristic way of processing information and a specific functioning of attention, particularly loosening of associations that makes it possible to draw remote and often untypical links as well as weakened inhibition that results in receiving considerably more stimuli from the environment not directly associated with the individual's current activity (see also Zabelina, Saporta, & Beeman, 2015). The author concludes (Eysenck, 1993, p. 163) that five independent sources of data and deduction confirm his theory: (1) people genetically related to psychotics often turn out to be eminently creative; (2) psychoticism is related to test-measured originality; (3) psychoticism is related to actual creative achievement, (4) creative individuals often suffer from psychopathologies, and (5) identical cognitive functioning styles are found in psychotics and in creative individuals.

Concluding, anecdotal evidence, analyses of highly creative people (Simonton, 1991), and theoretical predictions (Eysenck, 1993, 1995) posit the special effect of psychoticism on creative ability that mainly results in originality due to latent inhibition, and then, indirectly, in creative achievement (Eysenck, 1995). Although the relationship between creativity and psychoticism remains controversial (see Acar & Runco, 2012, for a recent meta-analysis) and although Eysenck's theory of personality has been less popular in the last decade than it used to be in the 1990s, at least some of its main assumptions and predictions are worth considering. A recent meta-analysis (Acar & Runco, 2012) shows that the effect is especially strong ($r = .50$) only when psychoticism is measured with the use of Eysenck's instrument – other operationalizations bring much weaker, although still significant, effects ($r = .16$). On the other hand, even if the postulated mechanism of the relationship between psychoticism and creativity is still to be confirmed, the role of psychoticism and psychoticism-like characteristics for creative people seems especially intriguing.

Empirical evidence confirms that aggressiveness predicts eminence in eminent creators (Simonton, 1991), echoing both classic studies and meta-analyses, while studies on ordinary people usually show a negative relationship between agreeableness (and, more broadly, stability) and creative self-beliefs (Karwowski & Lebuda, 2016) as well as negative effect of the Honesty-Humility personality trait on creative activity and achievement (Silvia, Kaufman, Reiter-Palmon, & Wigert, 2011). Similarly, a growing number of works on the relationship between constructs conceptually close to nonconformity and independence – i.e., schizotypy and creativity – may serve as an argument in favor of the role such traits play for creative functioning. Although generally equivocal (see Acar & Sen, 2013) and showing that it is positive (i.e. unusual experiences) rather than negative schizotypy (i.e., introvertive anhedonia) that is positively associated with creativity, the subtrait of schizotypy that is the closest to psychoticism – impulsive nonconformity – was found to predict divergent thinking (Batey & Furnham, 2009; see also DeYoung, Grazioplene, & Peterson, 2012, for a more complex theory associating openness with positive schizotypy).

Obviously, the variable-centered approach to creativity also focuses on a wide range of other characteristics and is not limited to creative ability, openness, and nonconformity. Hundreds of studies focus on various personality traits (Lebuda, Zabelina, & Karwowski, 2015) and cognitive descriptions (da Costa, Páez, Sánchez, Garaigordobil, & Gondim, 2015). However, the three broad groups of characteristics described above seem to be especially important from the educational perspective and for the analyses of creative contradictions.

Although on the surface creativity is among the most desired human characteristics, regarded as a fuel of psychological (Wright & Pascoe, 2015), economic (Florida, 2002), and cultural growth (Cooke & Lazzeretti, 2008), the decades of research into teachers' perception of creative students in the classroom give a much more nuanced and worrisome picture. An intriguing hypothesis was proposed by Dawson (1997), who summarized a wide body of research on teachers' attitudes toward creative children and concluded that although teachers are open toward and prepared to recognize creativity in those children who fit well into school requirements (so-called "briefcase" students), they are usually completely unprepared to do so in the case of more nonconformist students (so-called "wild bohemians"). The distinction between briefcase and bohemian students, which should be treated as a continuum rather than a dichotomy, stems directly from different level of nonconformity and to a large extent informs the person-oriented approaches, described below.

Consequently, although the variable-centered approach provides important insights into the characteristics of creative people, these characteristics are too often disjointed, closer to a mosaic of different and sometimes contradictory traits (Csikszentmihalyi, 1996) than to a coherent picture. It is likely that straightforward characterization is hardly possible because of the complex nature of the construct of creativity and its domain-specificity. On the other hand, approaches that are more person-centered (or actor-centered) than variable-centered may resolve this issue.

6.3 The Person-Centered Approach

On the most general level, what I mean by person-centered perspectives is approaches that rely on typological or profile analyses of individuals; their crucial characteristic is the focus on a person (or actor, see Glăveanu, 2013), with her or his strengths and weaknesses, rather than on the characteristics of creative people in general. Although typological perspectives have been at the heart of psychology since its prescientific period (see e.g., the Hippocrates-Galen typology; Strelau, 1998), their popularity in contemporary psychological theorizing is rather restricted. This does not mean, however, that such attempts are completely missing in the creativity literature; quite the opposite – at least a few different models developed in the last four decades may serve as examples of the typological approach.

What is more, some creativity scholars (Durmysheva & Kozbelt, 2014; Kozbelt, 2008; Kozbelt, Beghetto, & Runco, 2010) note that typological frameworks gain momentum in contemporary creativity literature due to their ability to bridge the gap between idiographic and nomothetic theorizing (see Durmysheva & Kozbelt, 2014) and may offer a valuable addendum to the dominant, variable-centered theorizing. A detailed overview of the existing typological approaches to creativity is beyond the scope of this chapter (see Kozbelt, 2008, for an overview), so below I discuss the most representative models only briefly and show their similarities and specificities. Their most visible similarity lies in the observation that there are different ways of being creative. Therefore, despite the differences in the level of creativity (assumed by the level-centered and variable-centered models), typological approaches highlight the style of creative functioning and the different faces creativity may have.

Although Maslow's (1967) primary and secondary types of creativity (with primary creativity oriented toward self-actualization and secondary creativity oriented toward creative achievement in certain fields) can be considered the first typological model, it is probably the "adaption–innovation theory," proposed in the mid-1970s (Kirton, 1976) and elaborated since that time (Kirton, 2004), that has become the most popular typological model in the creativity literature. This model was specifically meant to be used in analyses of people's functioning in organizational settings, but is also applicable outside organizations (Leong, Fischer, & McClure, 2014). In essence, Kirton's main assumption is that the level of creativity (i.e., divergent thinking or imagination) should not be confused with the style of creative functioning. In other words, people can be less or more creative, but at the very same time they can reveal their creativity in different ways.

The first style of creative functioning, typical for adaptors, is associated with a tendency to "do something better," i.e. with orientation toward incremental, within-paradigm changes rather than toward revolutionary discoveries and ideas. Innovators are characterized more by a tendency to "do something differently" – that is, by a tendency to make much more radical and revolutionary changes associated with paradigm-changing than by paradigm-improving behaviors. The huge popularity of the adaption–innovation theory stems at least in part from the fact that there is an instrument that enables the measurement of the tendency for adaptive versus innovative behaviors: the Kirton Adaption–Innovation Inventory (KAI; Kirton, 1976). This instrument measures sufficiency of originality, efficacy, and rule / group conformity. Here, adaptors are characterized by high efficacy and rule / group conformity, while innovators exhibit high originality and low efficacy and rule / group conformity.

Several other typological models presented in the creativity literature directly or indirectly allude to the adaption–innovation theory. For example, Kaufmann (1979) proposed two similar types: assimilators (people who prefer to use established ways while solving problems) and explorers (people seeking novel solutions). Similarly to the Kirton theory, explorers are not necessarily more creative than assimilators – although, as predicted, assimilators are more effective while solving problems that require insight (Martinsen, 1995).

Interestingly, in a study that compared Kaufmann's styles with the Kirton model (Goldsmith & Matherly, 1986) these two were not associated, which showed that although there is a similarity on the surface, these two styles and types describe different phenomena. Similarly, recent works on incremental and radical creativity (Gilson, Lim, D'Innocenzo, & Moye, 2012; Gilson & Madjar, 2011; Madjar, Greenberg, & Chen, 2011) show two different styles of creative functioning that form two separate factors rather than two ends of the same continuum. These two factors are, however, negatively correlated ($r = -.45$, Gilson et al., 2012), which argues for either incremental or radical type of creative functioning. What is more, similarly to previous works on the adaption–innovation theory, works on incremental and radical creativity show that radicals tend to be driven by intrinsic factors and incrementals by extrinsic factors (Gilson et al., 2012), which is consistent with the characteristics of adaptors and innovators (Amabile, Hill, Hennessey, & Tighe, 1994). Obviously, this is not to say that the incremental-versus-radical model ideally corresponds to the adaption–innovation model, but the relationships between them are clear.

Starting from a more cognitive perspective, De Dreu and his colleagues (Baas, Roskes, Sligte, Nijstad, & De Dreu, 2013; De Dreu, Baas, & Nijstad, 2008; Nijstad, De Dreu, Rietzschel, & Baas, 2010) developed the dual pathway to creativity model (DPCM) that proposes two distinct emotionally-cognitive paths leading to creative outcome. The first path is related to cognitive flexibility (i.e., flexible processing of information), while the second path – the cognitive persistence path – may lead to greater creativity thanks to detailed explorations of different possibilities and ways.

In a series of studies, De Dreu and his team demonstrated that the DPCM may integrate the often opposite findings reported in the creativity literature. They showed, for instance, that while quite typical correlates of creativity, such as openness, intrinsic motivation, or positive emotions are usually fruitful for creative production thanks to activating the cognitive flexibility path, the opposite characteristics – negative emotions, introversion, or neuroticism – may be fruitful for creativity as well, because of the activation of the persistence path.

Thus, the DPCM is an integrative model that focuses especially on different styles and processes related to creative activity. On the other hand, because previous research identified clear personality antecedents of both paths (see Baas et al., 2013, for an overview), there are good reasons to believe that the two paths are typical for (although not exclusive to) different groups of people. Those who are more open and extravert – people with a higher level of plasticity (DeYoung, 2006) – are characterized by the tendency to use the flexibility rather than persistence path. By contrast, the persistence path should be more typical for people who are agreeable and conscientious, although studies to date have demonstrated that it is rather negative affectivity and neuroticism that predict the persistence path to creativity. Therefore, although arguments in favor of linking innovators (to use Kirton's term) and explorers (to use Kaufmann's term) with the flexibility pathway do exist, it is much more equivocal to link adaptors and assimilators with the persistence pathway, although such a link seems to only be intuitively valid. Consequently, one may expect a tendency for radical creativity to be closely related to the flexibility pathway and for incremental creativity to be related to the persistence pathway. Future research should explore these relationships and test the hypotheses postulating links between the different models discussed above (see also Nowacki, 2012, 2014).

In recent years, the "finder–seeker" distinction proposed by Galenson (2004, 2005) and explored by others (Kozbelt, 2008; Kozbelt & Durmysheva, 2007; Nowacki, 2014; Simonton, 2007) has probably been the most widely explored typology of creativity. Finders, or "conceptual innovators," are creators who challenge the existing paradigms in their domain and do not care too much about tradition and previous achievements in the field. Consequently, they often produce their greatest works relatively early in their careers. Pablo Picasso is usually considered a prototypical finder (Kozbelt, 2008). More recently, Galenson proposes to analyze the finder and seeker categories not necessarily as types or as a dichotomy, but rather as a continuum. Seekers are defined as experimentalists who work in a detailed way and whose creativity is based on long preparation time and on the learning skills required by the domain. As a result, their achievements are usually observed relatively late in their careers – Cezanne is considered a model figure for this type of creator. It was argued and confirmed empirically that while the finder category is much more typical for "Western world creativity" (Nowacki, 2012), seekers are more often represented among Eastern creators (Kozbelt & Durmysheva, 2007). One of the predictions of Galenson's theory is that there are different proportions of finders and seekers in different domains – as domains and subdomains require different levels of skills and preparations (see Simonton, 2009; Szen-Ziemiańska, Lebuda, & Karwowski, in press). It may be safely assumed that while creators in some domains (e.g., poets) will tend to fall into the "finders" category, others (e.g., novelists) will tend to belong to the "seekers" category.

Simonton (2007) tested these predictions, but found the domain to be independent of the type, resulting in all four possible combinations: poets-finders, with the peak of creative production at 28 years, novelists-finders, with the peak at 34, poets-seekers with the peak at 38, and finally novelists-seekers with a peak at 44 years. Indeed, finders achieved their peak earlier than seekers and poets achieved their greatest achievement earlier than novelists, but the type was orthogonal to the domain. Importantly, similarly to all the models described above, Galenson's typology does not perceive either type as more or less creative – the differences relate mainly to the styles of functioning. Although it may be the case among Big-C creators, a study at the mini-c and little-c level demonstrated (Nielsen, Pickett, & Simonton, 2008) that, while solving problems, the experimental method (typical for finders) gives better results.

Clearly, although ostensibly clear links exist between adaptors, assimilators, and seekers as well as between innovators, explorers, and finders, more in-depth analysis shows as many differences as there are similarities. More specifically, adaptors, assimilators, and seekers share an incremental rather than radical approach. The difference between them lies mainly in the fact that while systematic, well-planned work with precise goals is typical for adaptors, it is much more characteristic for finders than for seekers, according to Galenson. Similar differences are visible between innovators (and explorers as well) and finders: while the broad scope of creative activities and sudden innovations are typical for both, seekers are more similar to innovators in their orientation toward trial-and-error problem solving, and in their tendency to work with less precise goals. Consequently, one can easily imagine adaptive finders and adaptive seekers as well as innovative finders and innovative seekers.

Probably the most complex typological model offered to date in creativity studies is known as the propulsion model of creativity (Sternberg, 1999, 2005; Sternberg, Kaufman, & Pretz, 2001, 2002, 2003, 2004). Understanding of creativity as propulsive stems from the observation that creative action usually pushes the field somewhere – sometimes the change is huge and sometimes it is very subtle and incremental. Sternberg and colleagues started with the observation that different types of creative contributions exist and they may be generally divided into types that work within the existing paradigm (generally accepting and developing it) and types oriented toward challenging and changing the paradigm.

Eight specific types are proposed within the propulsion model: replication, redefinition, forward incrementation, advanced forward incrementation, redirection, reconstruction / redirection, reinitiation, and integration (see Sternberg, 1999; Sternberg et al., 2001, 2002, 2003, for a more detailed description of all types). These types are perceived as differing in creativity style rather than in creativity level, which means they are not necessarily perceived as more or less creative. Replication and redefinition are such creative contributions that develop the field without changing its position – usually by focusing on small, incremental changes. Forward incrementation and advanced forward incrementation are oriented toward moving the field in the direction in which the field has already been heading, while redirection, reconstruction / redirection and reinitiation as well as integration move the field in a new direction. There are good reasons to believe that a broad description of different forms and types of creative contribution may not only allow for a more nuanced characterization of "different creativities" but also provide new insights and hypotheses about creative functioning. Essentially, although on the most general level the propulsion model divides different forms of creative contribution into "paradigm-accepting" and "paradigm-rejecting" ones, the variety of types in the propulsion model calls for a more nuanced and less dichotomous framing.

Less known but, for several reasons, consistent with the model presented below is the typological approach to teachers' creativity proposed by Cropley (2012). Based on three dimensions: the amount of novelty (low versus high), its kind (orthodox versus radical), and orientation toward product or process, Cropley distinguished eight different types of teachers, although this classification can be applied to other groups as well. People who propose ideas that are highly novel, characterized by a radical rather than orthodox novelty and focused on product instead of process, are called *innovators*. Those who are process-oriented as well as highly novel and radical in their novelty, are called *individualists*. *Adaptors* – the third type in Cropley's model – are people who are highly novel and product-oriented, but their novelty is orthodox rather than radical. *Pathfinders* are highly novel and orthodox as well as process-oriented. A low level of novelty combined with its radical character together with product-orientedness is typical for *avant-gardist*, while low and radical novelty plus orientation toward process is typical for *bohemians*. Finally, two less creative types are *sticklers*, who are product-oriented and propose a low amount of novelty of the orthodox variety, and *traditionalists*, who propose low and orthodox novelty and are process-oriented.

The typological models described above – from the adaption–innovation theory to the propulsion model of creative contributions and Cropley's creative types – serve as an inspiration and starting point for the typological theory of creativity (TTC).

6.4 The Typological Theory of Creativity

The argument made above leads to a clear message: cognitive as well as personality characteristics are crucial to a comprehensive description of a creative person. Consequently, one can imagine several and often contradictory (Csikszentmihalyi, 1996) lists of intellectual and personality traits associated with creative endeavor on different levels (from mini-c to Big-C) and in different domains (Feist, 1998). However, from the person or actor-centered perspective, these numerous characteristics may be efficiently limited to a narrower set of traits that are then used in the process of typologization. Obviously, the traits eventually used should be the most relevant and specific for creative individuals. After the discussion presented in the first part of that chapter, I propose that creative ability, openness, and independence should form such building blocks of a new typology.

Several reservations and qualifications should be kept in mind while analyzing the types I present below. First and foremost, although types are by definition stable, they are not carved in stone (see also Karwowski & Jankowska, in press). While the person-centered approach considers creative ability, openness, and independence as stable characteristics and, consequently, sees types as stable, this stability is relative rather than absolute. Types change with time as do their building blocks. Thus, to make the idea of a more flexible typology more clear, it is worthwhile to adopt an actor-centered (Glăveanu, 2013) rather than person-centered (Marsh, Lüdtke, Trautwein, & Morin, 2009) perspective when describing the types. The actor's analysis focuses on action and behavior rather than traits: it describes observable (or inferable) signs of creative ability, openness, and independence, without necessarily assuming their unchangeable nature.

Different configurations of creative ability, openness, and independence correspond to different creativity types. To date, analyses have mainly focused on four such categories: (1) "complex creativity" – a combination of high openness, independence, and creative ability; (2) "subordinated creativity" – a combination of high openness and creative ability and low independence; (3) "rebellious creativity" – a combination of high creative ability and independence and low openness, as well as (4) "self-actualizing creativity" – a combination of high openness and independence and low creative ability. The Monte Carlo simulation studies as well as primary studies empirically confirmed the postulated structure of the hypothesized types and several differences between them (see Karwowski, 2010a; Karwowski & Jankowska, in press). These differences apply, among other things, to school achievement of the types (Karwowski, 2010a) or to different patterns of their creative activity and achievement. In this part of this chapter, I focus mainly on two of these categories, i.e. subordinated and rebellious creativity, as they are not only clearly distinct, but also especially relevant for the educational reality.

Why focus on rebellious and subordinated creativity types and why are those specific types particularly important? Plenty of reasons for this likely exist, but four of them are of special interest from the school perspective. These four arguments and differences between the types in this respect, discussed below, are as follows: (1) their perception by teachers and their school functioning, (2) their school achievements, (3) potential differences in their creative process that directly translate into their learning, and, finally, (4) their functioning in the group while solving problems.

In school settings, subordinated and rebellious creative types mirror what Dawson (1997) called "briefcase" and "wild-bohemian" students – they may even be perceived as prototypes of such categories. Therefore, while the subordinated creativity type may not only be accepted but also welcome in the classroom (see Dawson, 1997; Karwowski, 2007, 2010b), the rebellious creativity type (the wild bohemian) is perceived as disruptive and behaving in an improper manner – a pattern that has been found in the creativity literature (Scott, 1999; Torrance, 1988). A recent study related to teachers' implicit theories of students' creativity (Gralewski & Karwowski, in press) has demonstrated that different patterns of creative students' perceived traits result in four classes of teachers who perceive creative students differently.

Interestingly, although two of these classes perceived creative students clearly in a way that stands in contrast to the creativity literature (e.g., as lacking ideas), and those two classes together amounted to more than one-third of all the participating teachers, the other two classes perceived creative students coherently with the assumptions concerning the subordinated and rebellious types. The class that perceived creative students consistently with the rebellious creativity type was larger, with almost half of all participating teachers (46 %) classifying them as belonging to it. The subordinated creativity type class was much smaller and covered about 20 % of all teachers. Thus, this study provides convincing evidence that the distinction between rebellious and subordinated creativity stems not only from an armchair classification but is also deeply rooted in teachers' naïve theories of creativity. Even more importantly, the same study demonstrated that the perception of those two types may be quite strongly gender-specific, with teachers perceiving female students as more subordinately creative and male students as more rebelliously creative.

The fact that the group of teachers who perceived creativity as more rebellious than subordinated is two times larger may explain why creative students face several problems at school – very likely because teachers perceive and define them as rebellious while underestimating the likelihood that creative students may also behave in a more adaptive, incremental, and subordinated way. It also sheds some new light on the sometimes observed situation (e.g., Gralewski & Karwowski, 2013) of greater space being allowed for boys' creativity than for girls' creativity in class (but see also Karwowski, Gralewski, & Szumski, 2015): even if teachers not always like wild bohemians (in fact, they often do not), at least they are aware of their existence due to such students' impulsiveness, energy, independence, or even ADHD (Radel, Davranche, Fournier, & Dietrich, 2015).

Paradoxically, in the case of the subordinated creativity type, the situation may not necessarily be better. Although such students are usually liked by teachers, they are not perceived as creative, or, to put it differently, they are perceived as less creative than rebellious creativity students. This shows that teachers' acceptance has little to do with those students' creativity and may be related mainly to the support of their school functioning but not necessarily to their creative endeavor. If this line of reasoning is correct, we should expect much more effective school functioning in the case of the subordinated creativity type but perhaps more space for creativity and more extracurricular activities when it comes to students representing the subordinated creativity type. But is this the case?

A recent study on Polish adolescents identified large groups of rebelliously creative students ($N=400$) and subordinately creative students ($N=700$). As expected, there was a clear gender effect –majority of the students representing the subordinated creativity type (65 %) were female, while majority of rebelliously creative students (62 %) were males. As hypothesized, the students who represented the subordinated creativity type were more effective in school functioning: they not only achieved better scores in standardized achievement tests and better grade point average but they also had a higher academic self-concept and perceived school climate as more positive. All these differences were not only statistically significant but also quite robust in terms of effect size and held even after controlling for the possible confounding effect of gender differences. Interestingly, however, and contrary to the expectations, students who represented the subordinately creative type were found to be more creative in terms of domain-general and domain-specific self-descriptions as well as declared intensity of creative activity in different domains. Thus, it looks like the lack of openness visible in the case of rebellious creativity makes creative activity and self-concept among students who represent this type especially difficult.

Do subordinate and rebellious creativity types differ in much more nuanced and dynamic aspects related to their process of learning rather than to their traits? Do the differences in school achievement mirror the differences in the process of problem solving and learning, especially creative learning? In the new, fresh perspective on creative learning (Beghetto, 2016), this process is divided into two spheres: intrapsychological (called "creativity in learning") and interpsychological ("learning in creativity"). The creativity-in-learning phase focuses on cognitive processes and, more specifically, on the role creativity plays in forming or changing the personal understanding of the studied concepts. The second, interpsychological phase (creativity-in-learning) focuses on sharing this personal understanding with others. The creative learning perspective is still new and requires further research, but it may scaffold thinking about creative types. Due to the specificity of types, it is possible to speculate about possible differences between them with respect to the creativity-in-learning and learning-in-creativity phases.

The intrapsychological process of creative learning is based mainly on students' ability to attend to optimally discrepant learning stimuli, to combine these stimuli with the existing knowledge, and to interpret this new combination of "already known" and "just discovered." Although this process is assumed to be general – i.e., to operate in a similar way among people who differ in terms of specific individual traits – there are good reasons to believe that the two types described above may have different thresholds for optimally discrepant stimuli. Due to clear differences in openness, their sensitivity to new stimuli as well as their ability to effectively integrate the new stimuli with the existing knowledge may differ. As people who represent the subordinated creativity type are more open, they should more readily notice new stimuli, but their ability to combine these stimuli with existing knowledge is less obvious. On the contrary, rebelliously creative people are probably relatively less sensitive to new stimuli due to higher rigidity (lower openness) – but when the stimuli are realized, they may quite effectively combine with the existing knowledge thanks to more remote associations made. However, there is a serious risk that rebelliously creative people will treat irrelevant stimuli as important in the learning process, which, eventually, will lead to highly new but inappropriate solutions and ideas, which, by definition, cannot be counted as creative.

This assertion is of special importance when it comes to the second phase of the creative learning model – the interpsychological sphere. As Beghetto (2016) points out, the personally meaningful concepts and understandings have to be socially validated during the socialization process and by means of feedback from others. Subordinately creative people may have problems with sharing their ideas with others and with defending them when criticized. However, on a more general level, their ideas are often original as well as appropriate (perhaps more appropriate than original), so the feedback is usually positive. According to the self-efficacy theory (Bandura, 1997), it forms a mastery experience and translates into higher self-efficacy (Karwowski & Barbot, 2016) – a finding we have observed earlier when subordinately creative students were found to have higher creative self-efficacy.

Rebelliously creative people not only present ideas that are sometimes too wild to be socially regarded as creative, but they also tend to fight for them with their peers and teachers. This leads to a higher ratio of rejection in the case of such ideas, and – as a consequence – to a decrease in the creative self-concept and creative activity of individuals who represent this type. Indeed, it requires considerable effort do defy the crowd (Sternberg & Lubart, 1995), and this defiance is especially challenging at school.

The hypothesized advantages and weaknesses of both analyzed types in the intra- and interpsychological spheres may lead to the expectation that some balance will be achieved when these two types are allowed to work together while learning or solving problems. Indeed, this seems plausible if we bear in mind the effectiveness of collaborative learning in general (Slavin, 1996) and in creative thinking (Hämäläinen, & Vähäsantanen, 2011). It would be naïve, however, to expect that simply bringing together subordinately and rebelliously creative people in one group will lead to synergetic effects (Glăveanu & Karwowski, 2015).

Obtaining synergy in the group process is much more complicated and requires team-relevant creative processes (Pirola-Merlo & Mann, 2004; Taggar, 2002), effective leadership (Reiter-Palmon & Illies, 2004), and trust (Barczak, Lassk, & Mulki, 2010). However, if this process of group creativity is led effectively (Sawyer, 2014), chances for synergy increase. As a typical class is composed of students with different creativity profiles, it makes much sense to work on new interventions aimed at enhancing their effective collaboration, which should lead to their more effective functioning while solving problems or learning.

6.5 Discussion

Person- or actor-centered approaches combine idiographic and nomothetic theorizing, which is why their popularity in creativity science is growing. Thinking not only in terms of personality or cognitive traits but also in terms of their combinations resulting in specific types may provide more comprehensive explanations of different, often contradictory, patterns of creative people's functioning. In this chapter, drawing heavily on previous variable- and-person-centered approaches, I focused especially on the latter and argued that for the educational psychology of creativity a question equally as important as how much creativity the student possesses (i.e., How creative are you?) is what type of creativity he or she represents. It may even be stated that the type is more important than the level, because the level of creative ability may be quite effectively enhanced (Dziedziewicz, Gajda, & Karwowski, 2014; Dziedziewicz, Oledzka, & Karwowski, 2013; Karwowski & Soszynski, 2008; Scott, Leritz, & Mumford, 2004), while personality traits that constitute the types are relatively stable (McCrae & Costa, 1994). This, however, is not to say that types are unchangeable or that they are always dichotomous.

Types provide a heuristic framework and should be treated as specific styles and patterns of behaviors related to creative activity. Hence, although there is probably a limited number of clear adaptors or innovators (or finders-seekers, assimilators-explorers, etc.), different people generally show tendencies toward one or the other type or style of behavior. These tendencies are hypothetically caused by personality and cognitive factors, but this is not to say that social elements do not play any role here. Quite on the contrary – in different situations and depending on the audience, the very same person may behave differently and be classified into two or three different types, depending on social environment. Consequently, the actor-based approach to types (see Glăveanu, 2013) stresses the behavior-based rather than trait-based perspective. Even if behaviors depend on traits, social activity is often associated with playing different roles and with adjustment to the situation and audience. It may therefore be hypothesized that types may be much more dynamic than person-centered theories assume.

The typological model of creativity places special emphasis on four types of creativity: rebellious, subordinated, self-actualizing, and complex. Taking into consideration the dynamic character of these types, we should probably refer to them as different creativities rather than stable creativity types. From the double perspective of this volume that focuses on both contradictions and education, the subordinated and rebellious creativity types were analyzed in greater detail. These two types resonate perfectly with the prototypical naïve theories of creative students held by teachers who define such students either as adaptors (briefcase) or as innovators (wild bohemians) (Gralewski & Karwowski, in press).

Going further, the similarities and differences between these two types may help to explain the contradictory findings observed in literature to date. For instance, although a recent meta-analysis shows that creativity is positively related to school achievement (Gajda, Karwowski, & Beghetto, in press), some literature shows a negative relationship between creative ability and school achievement as well (Vijetha & Jangaiah, 2010). It is plausible that noncognitive characteristics moderate the relationship between creative ability and school functioning.

Openness not only positively translates into school achievement (Poropat, 2009) but may also qualify the relationship between creative ability and school success. A high level of nonconformity, especially if it means disagreement with a teacher, may further hinder the chances of translating creative abilities into successes. This is exactly the pattern that was observed among subordinately and rebelliously creative people: those described as subordinately creative coped with school much more effectively than those described as rebellious, although their level of creative ability was virtually the same. Thus, it was likely a specific profile of non-cognitive characteristics that resulted in the higher school achievement and academic self-concept of these students. Even more importantly, the structure of creativity-related predictors of school achievement clearly differed between these two types, suggesting different mechanisms behind their school functioning.

Interestingly, subordinately creative students not only did better at school than rebelliously creative students, but they also held a more creative self-concept and declared more intensive creative activity. This pattern – somehow surprising as types did not differ in terms of ability – requires further research, but it may suggest that due to their wild (i.e., original but not necessarily useful) ideas, rebelliously creative people may get more negative feedback from their peers and teachers, which hinders their creative self-efficacy and creative activity.

It is also possible that rebelliously creative people lack the awareness of their own potential – i.e., creative self-efficacy (Beghetto, 2006; Karwowski, 2011) or creative metacognition (Kaufman & Beghetto, 2013) – or that they perceive creativity mainly as a fixed characteristic (Karwowski, 2014; Karwowski & Barbot, 2016) and do not consider it as subject to change. What is more, it was speculated that the process of creative learning hypothesized by Beghetto's (2016) model may differ between these two types. Future studies that would combine microdynamic observational studies and rigorous learning studies, should examine whether the suppositions presented above find confirmation.

Concluding and returning to the contradictions this volume focuses on, it should again be highlighted that not only great creators' personalities combine opposite traits (Csikszentmihalyi, 1996; Feist, 1998); also people at the mini-c or little-c creativity levels (for instance students) may behave in a completely different manner, even if they have the very same level of creative ability. The actor-centered approach proposed in this chapter calls for an in-depth analysis of the determinants and consequences of belonging to one of the four types of creativity, arguing further that such a typological approach may be especially useful while explaining the contradictory findings obtained over the decades in the educational psychology of creativity.

In sum, it is not only important how much creative ability our students have – after all, their imagination or divergent thinking may be effectively enhanced (Scott et al., 2004). What is equally important is in what way our students' creativity is expressed. Is it expressed in a wild-bohemian, rebellious way or in an adaptive and polite way? Is it based on incremental or radical changes? Is it conciliatory when it comes to taking criticism from others or seditious and ready to put up a fight? The intuitive fit of creativity types into teachers' naïve theories (Gralewski & Karwowski, in press) as well as their explanatory power in discussing the functioning of different kinds of creative people in school settings warrants further research in this area.

6.6 At the End – Take Home Messages

- Creativity is a multifaceted phenomenon, and its description requires nomothetic as well as idiographic perspectives.

- Style of creative functioning may be – and often is – equally as important as the level of creative ability student has.
- Different levels of creative ability, openness and independence yield four distinct creativity types: complex creativity, subordinated creativity, self-actualizing creativity, and rebellious creativity.
- When at school, the distinction between subordinated and rebellious creativity has special potential to explain different challenges creative students may face: while subordinately creative students are usually well-adapted to school settings, rebelliously creative students may often behave in a way that is not-accepted in school.

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Chapter 7
Purposeful Fulfillment of Creative Potential

Pablo P.L. Tinio and Baptiste Barbot

Abstract Creativity is a skill that many consider essential for success in school, career, and life (Florida, The rise of the creative class. Basic Books, New York, 2002; Florida, The flight of the creative class: the new global competition for talent. HarperBusiness, New York, 2005; Guilford, Am Psychol 5:444–454, 1950). For this reason, creativity has become an imperative. Companies want employees who can create the next popular app or who can shake up the industry with an innovative product, process, or idea. Teachers want creative students who can take knowledge that they are taught and apply it in new ways. And parents want creative teachers who can deliver ideas in interesting and engaging ways to their students. Although creativity can have a *dark side* (Cropley, The dark side of creativity: what is it? In: Cropley DH, Cropley AJ, Kaufman JC, Runco MA (eds) The dark side of creativity. Cambridge University Press, Cambridge, pp 1–14, 2010), it is generally seen in a positive light—that creativity is beneficial. It is therefore no surprise that many attempts have been made to promote and nurture creativity (e.g., De Bono, Serious creativity: using the power of lateral thinking to create new ideas. HarperCollins, New York, 1992; Renzulli, The three-ring conception of giftedness: a developmental model for promoting creative productivity. In: Sternberg RJ, Davidson JE (eds) Conceptions of giftedness. Cambridge University Press, Cambridge, pp 217–245, 2005). Although many resources have been expended on such creativity training, the results have been mixed (Plucker, Beghetto, Dow, Educ Psychol 39:83–96, 2004). This is partly because creative behaviors that really make an impact within genuine contexts, such as schools and workplaces, are difficult to teach (e.g., Nickerson, Enhancing creativity. In: Sternberg RJ (ed) Handbook of creativity. Cambridge University Press, Cambridge, pp 392–430, 1999).

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7.1 Introduction

Creativity is a skill that many consider essential for success in school, career, and life (Florida, 2002, 2005; Guilford, 1950). For this reason, creativity has become an imperative. Companies want employees who can create the next popular app or who can shake up the industry with an innovative product, process, or idea. Teachers want creative students who can take knowledge that they are taught and apply it in new ways. And parents want creative teachers who can deliver ideas in interesting and engaging ways to their students. Although creativity can have a *dark side* (Cropley, 2010), it is generally seen in a positive light—that creativity is beneficial. It is therefore no surprise that many attempts have been made to promote and nurture creativity (e.g., De Bono, 1992; Renzulli, 2005). Although many resources have been expended on such creativity training, the results have been mixed (Plucker, Beghetto, & Dow, 2004). This is partly because creative behaviors that really make an impact within genuine contexts, such as schools and workplaces, are difficult to teach (e.g., Nickerson, 1999).

This difficulty lies at the heart of the creative contradiction about which we are writing this chapter: how and what we teach about optimizing creativity is misaligned with how creativity is actually expressed in genuine contexts and how creative potential is fulfilled during the life of an individual. Teaching creativity in one context (e.g., in the classroom) might not translate to creative behaviors in another context (e.g., in a workplace). In addition, the teaching of how to optimize creativity should not be approached as a short-term process. Instead, it should be seen as a lifelong process that requires personal nurturing and facilitating of one's decision to fulfill creative potential. The process requires agency.

In this chapter, we propose the *purposeful fulfillment of creative potential view*, which focuses on the long-term (and lifelong) fulfillment of creative potential within genuine contexts. As we will describe, this view sees creative activity as primarily domain-specific instead of domain-general; as an active process as opposed to a passive process; as something that can be invested in multiple domains (with specificity within each domain) instead of a single or even a few domains; and as involving a lifelong process of development, which stands in stark contrast to quick, short-term, and closed-ended methods of teaching creativity. Each of the above dichotomies could be considered as contradictions of their own. One of the defining characteristics of the *purposeful fulfillment of creative potential view* is its close tie to developmental trajectories of creativity.

7.2 Development of Creativity and Purposeful Fulfillment of Creative Potential

Kaufman and Beghetto's (2009) *Four C Model* of creativity is a useful model that describes qualitatively distinct stages of creativity development. The development of creativity is generally described as a non-linear, often discontinuous, process throughout the lifespan (illustrated by periods of "peaks" and "slumps"; e.g., Torrance, 1968), and the Four C Model is well suited for describing the various ways creativity is expressed—from simple creative insights in the classroom to extraordinary creative accomplishments. The first *C* in the Four C Model is *mini-c* creativity, which describes the natural developmental aspect of creativity. Mini-c creativity refers to "the novel and personally meaningful interpretation of experiences, actions, and events" (p. 73, Beghetto & Kaufman, 2007). It is the type of creativity that is expressed at a personal level and is independent of external evaluation by judges, experts, or society. Mini-c also refers to creativity during the learning process in which the learner experiences an insight that is personally creative, but not outwardly groundbreaking (Beghetto & Kaufman, 2007; Kaufman & Beghetto, 2009).

The second type of creativity, according to the model, is *little-c* creativity. Examples of little-c creativity include a home cook coming up with a new method for tenderizing meat before it is put on a grill, a technique all of his friends and relatives then use in their own cooking; a teacher making a school-wide change to the curriculum, which subsequently increases students' motivation to learn; and a middle-school soccer coach developing a new practice drill that significantly increases the stamina of players in her team, helping them win their league. In all of these examples, creativity occurs within everyday settings and there is some recognition by others that the actions are indeed creative (Kaufman & Beghetto, 2009).

Although not always the case, *Pro-c* creativity could be seen as an extension of little-c creativity (Kaufman & Beghetto, 2009). Taking one of the examples, the middle-school soccer coach could continue to hone her craft and attend formal coach training courses. After many years of continuous training and coaching various teams, this person could eventually become a coach of a professional soccer team and continue to develop creative techniques for training players, but at a professional level.

Finally, *Big-C* creativity is what many people would associate with the eminently creative—such as Picasso and Matisse in the arts, Schubert and Vivaldi in music, Newton and Einstein in science, and Jobs and Gates in technology. Big-C creativity is rare and often requires a posthumous evaluation, and even a lifetime of training and developing expertise within a given domain does not guarantee that a person could reach this level of creative accomplishment (Kaufman & Beghetto, 2009).

Kaufman and Beghetto (2009) use the Four C Model to describe possible developmental trajectories of creativity, punctuated by various transitional periods. Any trajectory begins with mini-c creativity regardless of the outcome. Within nurturing and motivating conditions, mini-c creativity could progress into little-c creativity. With encouragement and education, little-c creativity could then turn into Pro-c creativity. Although atypical, Pro-c creativity could progress into Bic-C creativity, but only very few individuals working in optimal contexts are able to reach this eminent level.

The *purposeful fulfillment of creative potential view* presented here is at the heart of the developmental progression outlined in the Four C Model of creativity. Specifically, the purposeful fulfillment view proposes the following:

1. All transitional periods in the development of creativity (i.e., the progression from mini-c to little-c, or mini-c progressing into Pro-c and/or Big-C creativity), signify some degree of fulfillment of a person's creative potential.
2. The developmental progression from mini-c transpires more deliberately than has been previously conceived. In this view, the person is seen as an active agent during the lifelong process of fulfilling one's creative potential.
3. Purposeful fulfillment requires deliberate *investment* and *specialization* of one's creative potential in one or more domains of interest.
4. Purposeful fulfillment can be taught.

The fulfillment of a person's creative potential therefore involves explicitly teaching the individual how creativity should be personally facilitated within multiple domains and how to actively and deliberately fulfill one's creative potential. This approach lies in stark contrast to the view that at some point during a person's life, she might passively "bump into" and find the creative niche that matches the personal resources that she possesses—such as her personality, motivation, talent, and skills (Barbot, Besançon, & Lubart, 2015). Furthermore, if contextual conditions are optimal—such as having supportive parents or caregivers who spend money to provide for relevant experiences, special classes, private lessons, and so on—the person could progress from mini-c to a more profound expression of her creative potential, and she could ultimately achieve successful fulfillment (as judged by others) of her creative potential. The idea of purposeful fulfillment extends this process by attributing greater agency to the individual therefore acknowledging that a person is not merely passively going through life, and in the most optimal circumstance, will find her creative niche, but instead, should actively seek it. In order to do so, a person must pursue many mini-c's and little-c's in various domains.

7.3 Domain Generality vs. Domain Specificity of Creativity

Kaufman and Beghetto (2009) believe that mini-c and little-c creativity likely involve both general- and domain-specific factors and that Pro-c and Big-C creativity involve primarily domain-specific factors. This is related to the ongoing debate about the domain specificity (rather than domain-generality) of creativity. There is indeed much evidence that creativity is a multifaceted and partly domain-specific entity across the various "stages" of the Four C Model. Most evidently, the rarity of Big-C achievement in more than one creative domain (Gray, 1966) is strong evidence that creativity is mainly a domain-specific construct. This conclusion is also largely true at the mini-c, little-c, and Pro-c levels, as illustrated by multiple studies showing low to moderate correlations (typically in the .10–.30 range) between indicators of creativity across different domains (Carson, Peterson, & Higgins, 2005; Kleibeuker, De Dreu, & Crone, 2013; Lubart & Guignard, 2004; Plucker & Runco, 1998; Silvia, Kaufman, & Pretz, 2009) and only moderate correlations between indicators of creativity within the same domain (Baer, 1994), thus indicating the domain specificity of creativity and the importance of specific task-relevant resources within any creative outlet.

In many respects, these results taken together stand in contrast to the classic "*g-factor view*" of creativity (see Barbot & Tinio, 2015 for a critique of this view). Indeed, regardless of the developmental stage (from mini-c to Big-C), or the quality of creative outputs, each domain, subdomain, and even each specific creative task within a subdomain partly requires a different set of resources in order for a person to accomplish creative outputs recognized as valuable in that particular context. Even at the mini-c level, which involves a learner's "personal insight," creative accomplishment will not be independent of content, and therefore, will require a set of personal resources that are partly defined by the requirements of a domain or task. As a result, people will usually not produce creative outcomes of consistent quality across domains and tasks (because it is not likely that they will show a consistently efficient set of resources for a wide range of domains).

This view is consistent with the *Amusement Park Theory* (Kaufman & Baer, 2004) and other "hybrid" models of creativity (e.g., Amabile, 1996; Barbot et al., 2015; Plucker & Beghetto, 2004), which suggest that creativity simultaneously requires a set of general, a set of domain-specific, and a set of task-relevant resources to lead to creative outputs. Extending this view, a person has innumerable possibilities as far as creative potential—defined as the "quality of fit" between a person's unique set of resources (some being domain-general and some being domain- and task- specific) and the demands of each creative task (Barbot et al., 2015; Barbot, Lubart, & Besançon, in press; Barbot & Tinio, 2015).

Because all creative tasks are different, there are limited chances that a person's unique set of resources fits optimally with multiple, or even just one, set of demands and requirements of a creative task. Most creative outputs will be of average or low creativity, and Big-C achievements (reflecting an "optimal fit" between individual resources and given task demands) will be extremely rare (Barbot et al., in press). Because it is not likely that multiple creative tasks across domains will require the same "optimal" combination of personal resources, this view also helps us to understand why creativity mainly seems like a domain-specific entity.

It is important to note that a person's creative potential may never be fulfilled if the person does not have the opportunity to engage in a given creative outlet, or does not decide to invest time and energy in that outlet (Amabile, 1996; Barbot et al., in press). In that sense, the *fulfillment* of creative potential is *purposeful* and individual inclinations, interests, and personal investments remain at the center of the transitional periods associated with the realization of creative potential (similar to the transitions in the Four C stages). These drivers of fulfillment are intensely shaped by environmental influences and experiences. Therefore, two stipulations for the teaching of purposeful fulfillment of creative potential are that: (1) children should be explicitly taught that the fulfillment of creative potential is largely a personal decision, and (2) purposefully extending the range of outlets in which they have the possibility to express their potential increases the odds that they will actually fully realize their potential.

7.4 Specialization-Differentiation Hypothesis

Based on evidence from the field of cognitive and developmental neuroscience (e.g., Fink, Benedek, Grabner, Staudt, & Neubauer, 2007; Kleibeuker et al., 2013; Razoumnikova, 2000; Sawyer, 2011), we recently outlined how creative potential development involves the processes of specialization and differentiation through the formation of commitments and interests within a set of creative outlets (Barbot & Tinio, 2015). This process is most evident during adolescence, a time during which biological maturation processes take place. Importantly, adolescence is also a crucial time for the formation and crystallization of identity and personal commitments (Luyckx, Goossens, & Soenens, 2006). Specifically, the *Specialization-Differentiation Hypothesis* suggests that the formation of commitments within a limited set of creative domains or sub-domains may lead to the specialization of a person's creative potential in these specific outlets.

Accordingly, a critical driver of creativity development may not be a general thinking process (similar to the *g-factor* of intelligence), but rather, one's commitment to a specific domain or creative outlet (or outlets) of interest. By specializing, voluntarily or not, the differentiation of one's creative potential could take place (i.e., development of a set of "specialized" skills needed for that particular outlet). This process looks very much like the transition from mini-c or little-c to Pro-c creativity. Commitment to a creative task is an essential component of creative accomplishment, because it strengthens the underlying motivational component, and also because as people invest in a specific domain, they develop expertise in that domain, and consequently, they usually devote less time to other areas.

The specialization-differentiation hypothesis is consistent with the idea that individuals "themselves" could make creativity a domain-specific ability by engaging in an area that interests them (Plucker & Beghetto, 2004). Environmental influences, in particular the school environment, also interacts with one's creative investments in various outlets. For example, the loss of one's willingness to pursue a particular creative aspiration following negative feedback or performance outcome has been referred to as "creative mortification" (Beghetto, 2014; Beghetto & Dilley, in press). Creative mortification highlights the agency of individuals in their decision to invest or disinvest their creative potential in specific outlets.

7.5 Facilitating Purposeful Fulfillment

Having the realization that one has some control over the fulfillment of one's creative potential is empowering. It allows a person to take some creative insight—that might not necessarily be considered creative by others—to another level. Moreover, this process could occur not just in one aspect of life, but instead in several aspects (e.g., different domains of creative endeavor), potentially even simultaneously at different levels of creativity. However, to facilitate this process, knowledge about the process itself must be taught and facilitated by external agents—parents, teachers, and other people who play important roles in a person's life.

In order to help facilitate the purposeful fulfillment of creative potential, one of the most significant lessons that children can be taught is that they must use personal resources in order to realize their creative potential. This idea of investment is the basis for the *investment theory of creativity*, which refers to a person investing resources in the early stages of creativity. This could involve a creative insight that might not initially appear to have the potential to transform into something tremendously creative. Investment on such insight involves the decision to "buy low." However, with perseverance, an optimal environment, and the appropriate use of resources (e.g., time and effort), this mini-c could become something more profound and substantial, which the individual could then "sell high" (Sternberg & Lubart, 1991, 1995). This theory nicely captures the decision-making aspect of the purposeful fulfillment view. In fact, Sternberg and Lubart (1991, 1995; also see Sternberg, 2006) recognized the importance of seeing creativity as a decision.

The purposeful fulfillment view takes this idea one step further by conceptualizing decision making about creativity as a long-term—perhaps lifelong—process. Despite the idea of necessary specialization in one or a few creative outlets, this process could occur in multiple domains, possibly simultaneously, at different rates. The condition needed for this to happen involves the realization that creative potential can be invested in multiple creative outlets, thus increasing the odds of finding an optimal fit between one's specific set of personal resources and various tasks requirements. Therefore, the purposeful fulfillment view envisions long-term investment in multiple domains as a promising strategy that can be taught to children. Accordingly, the fulfillment of creative potential is situated at a meta-level: instead of focusing on explicit teaching of skills for being creative at a specific task, it aims to promote a mindset for having agency in how our creative potential (or potentials) could be fulfilled over the lifespan.

An important aspect of investing in a nascent, early creative insight is to commit personal resources to pursuing it. It is important to keep in mind that such commitment could be long-term so that creativity could be given a chance to evolve and express itself more fully. Long-term commitment is consistent with research on the influence of practice on performance (such as in chess or various types of music and sports), which has shown that it takes approximately 10 years (or 10,000 h) of practice in order for someone to become an expert in a given domain. What is important to keep in mind is that merely putting in the hours is insufficient for improvement.

Deliberate, focused, and effortful practice is required (e.g., Ericsson, Krampe, & Tesch-Römer, 1993). Performance gain is also optimal when metacognitive strategies are used (e.g., Pintrich & De Groot, 1990).

In addition, a recent meta-analysis related to the 10,000-h or 10-year rule, by Macnamara, Hambrick, and Oswald (2014), provides evidence that the effects of deliberate practice are domain-specific. Their analysis included 88 studies that met the inclusion criteria and that covered a variety of domains including music, sports, games, education, and professions. They found that the effects of deliberate practice on performance are relatively strong for games, music, and sports, but less so for education and professions. In other words, the effects of pursuing an activity for 10-years or 10,000 h depend on what it is that you are doing.

When considering investment of resources, it is also important to distinguish between long-term commitment to a particular activity and long-term commitment to working out a creative idea. The former involves an entire activity (e.g., playing the piano, writing poems, composing music) each of which is comprised of a combination of skills (e.g., writing poems involves an extensive vocabulary and associative thinking skills; Barbot & Tinio, 2015). The latter involves being receptive to how the initial creative idea could evolve or could be developed over time, a mindset central to the purposeful fulfillment view. Along with this mindset, children must be taught that as they commit themselves to pursuing creativity in different domains, each domain has specific demands and constraints.

7.6 Two Illustrations of Purposeful Fulfillment: Creativity in the Arts and in the Sciences

We could examine two distinct domains, the arts and sciences, to illustrate how the *purposeful fulfillment of creative potential view* could be approached in terms of the above discussion. The arts and sciences have traditionally been seen as contrasting disciplines. Here we could apply Li's (1997) conceptualization of creativity in vertical and horizontal domains. In vertical domains, creativity must occur within certain constraints and must incorporate stable elements of a domain. Thus, there is a limit to the extent to which creativity could be expressed, and the potential for novel deviations from past practice is limited. This is less the case with creativity in horizontal domains where there are fewer constraints on the amount of deviation from past practice and less demand to incorporate existing elements. Creativity in horizontal domains is therefore less predictable.

The arts could generally be considered more of a horizontal domain while the sciences could be considered more of a vertical domain (Li, 1997). One of the hallmarks of the sciences is the conformity to the scientific method, a set of principles that although are usually implicit and unspoken, nonetheless guide the work of scientists in fields such as physics, chemistry, biology, and psychology. As a vertical domain, a scientist working in any of these fields must follow the scientific method when conducting experiments as well as build their work on previous relevant literature and findings. These are much more pronounced constraints as compared to a horizontal domain such as modern and contemporary visual arts where the emphasis is on novelty and deviation from what others have done before. Cases in point in modern painting are Picasso's *Demoiselles d'Avignon* (c. 1907; Penrose, 1981), Jackson Pollock's drip paintings (Perl, 2005), and Rauschenberg's *Erased de Kooning* (1953; Stevens & Swan, 2004). Feist (1998) even found that artists' personalities were characterized by rejection of group norms much more so than scientists.

Domains then have very specific characteristics that define them, and these characteristics influence, and at times constrain, how creativity is expressed. As far as facilitating purposeful fulfillment, it is important to go beyond telling children to be creative and teaching them how to be creative. It is necessary to provide them with knowledge about meta-level issues and factors that they should keep in mind when engaging in a domain. Examples of such knowledge include the extent to which a field is receptive to novelty and what factors could constrain the expression of creativity. For example, when pursuing creative ideas in art (e.g., painting), they have opportunities to deviate, perhaps extremely, from what others have done before. However, they must still keep in mind that even with extreme deviations—such as in the choice of materials and how they are used—the concept and methods behind their work must still be rigorously developed (Tinio & Leder, 2013); they are not just going for novelty for novelty's sake. They should know that this approach to creativity in art is different from creativity in science.

7.7 Creative Self-Beliefs and the Purposeful Fulfillment of Creative Potential

With environmental influences sometimes supporting, sometimes impeding the fulfillment of creative potential and possibly leading to creative mortification (Beghetto, 2014), purposeful fulfillment of creative potential may take a great deal of persistence, resilience, and self-confidence. Therefore, a viable direction for encouraging purposeful fulfillment of creative potential may be to capitalize on students' *creative self-beliefs*, which refer to their convictions about their own creative potential, achievement, and identity and to their perception of what creativity is (Karwowski & Barbot, 2016). For example, teaching for fulfilment of creative potential could focus on forming students' creative self-beliefs and focusing on the concepts of self-agency and multidimensional fulfillment. An opposite yet complementary perspective was previously suggested by the pioneers of humanistic psychology who conceptualized creativity as a natural fulfillment of the self and a mechanism for achieving one's potential (e.g., Maslow, 1958; Rogers, 1954). In this view, traits such as self-acceptance and self-esteem were described as general features of creativity that may contribute to this natural fulfillment (Coopersmith, 1967). By extension, the *purposeful fulfillment of creative potential view* could teach children to explore the outlets that may help them fully realize their creative potential, reinforcing their creative identity in that domain, and in turn, increasing the odds of successful creative achievements (Helson & Pals, 2000).

There is a solid and growing area of literature focusing on the role of self-beliefs on creativity. In particular, creative personal identity (importance given to creativity in the definition of the self) and creative role identity (fulfillment of the "social role" for someone who is creative) have been related to creative outcomes in several domains (e.g., Jaussi, Randel, & Dionne, 2007). For example, past creative achievements will shape creative self-efficacy (Beghetto, 2006) and reinforce creative personal identity. If creative attributes are part of one's self-definition (creative self-concepts), the person will seek multiple experiences that will confirm this important dimension of identity. The literature on self-concepts in general (not necessarily in creative domains), and "investment" theories of self-concept in particular, suggests that self-concepts determine interests, which then translate into activity, effort, and perseverance. This, in turn, leads to achievement (e.g., Ackerman & Heggestad, 1997). Alternatively, the *expectancy-value theory* (Wigfield & Eccles, 2000) suggests reciprocal relations between domain-specific achievement, self-concept, and personal interests. According to this theory, both achievement and self-concept reinforce and are reinforced by personal interests. Regardless of the causal nature of the relationships among self-concept, achievement, and personal interests, this dynamic highlights one possible mechanism of the specialization of creative potential, and re-affirms the role of agency in creative potential fulfillment.

Metacognitive aspects of creative self-beliefs are also relevant to promoting the purposeful fulfillment of creative potential. They refer to a combination of creative self-knowledge and contextual knowledge (e.g., knowing when to be and when not to be creative; Kaufman & Beghetto, 2013). For example, a fixed creativity mindset—the implicit idea that creativity is mainly an innate property and cannot change—is strongly associated with mortification of creativity (Beghetto, 2014). "Resilience" in the face of negative feedback or performance outcomes, thus leading to the continuation of creativity, may be mainly related to the growth mindset—the idea that creativity is not a fixed property and can grow and change. The growth mindset could be encouraged in children such that they pursue their creative endeavors regardless of external pressures, feedback, and outcomes that could discourage them from doing so. By extension, explicitly teaching children that this applies to every single domain and subdomain may encourage them to pursue multiple creative endeavors, and in turn, increase the likelihood of fulfilling their potential. It is however important to note that this might not always be appropriate for all children, in particular for the youngest children. Viewing creativity as a personal attribute (rather that just as an action) only appears around the age of ten (Karwowski & Barbot, 2016), along with the understanding that creativity is a multidimensional and domain-specific ability (e.g., Rostan, 1998).

7.8 Fulfillment of Creative Potential: From Individual to Society

The *purposeful fulfillment of creative potential view* sees the individual as a powerful change agent who has a great deal of control over how creativity is expressed and to what extent creative potential is fulfilled. Such fulfillment is individualized—it depends on factors such as the resources a person possesses, what and how many creative domains such resources are invested in, and characteristics and demands associated with each domain. What is important is that caregivers and educators take it upon themselves to help children achieve fulfillment. The fulfillment of creative potential is a long-term, perhaps life-long manifestation. Although the above discussions have focused solely on individuals, purposeful fulfillment has positive ramifications that go beyond the individual.

Take a group of children that have all been taught the idea that creativity is a decision and that they could each dictate the extent to which their creative potentials could be fulfilled. This group of children could then serve as a stable base for exploring different avenues leading to fulfillment and as a barrier against negative feedback and creative mortification (Beghetto, 2014). The children in the group could motivate each other, promote each other's creative works and accomplishments, and serve as constructive critics of ideas. In this way, the children will not only learn how to approach the fulfillment of their own creative potentials, but also how to be optimally receptive to the creativity of others. Indeed, *Big-C* creative achievement depends not only on the groundbreaking nature of a given creative product, but also on the general context of time and place (Barbot & Tinio, 2015) and the way this creative product is valued by an audience (i.e., recognized as groundbreaking, appreciated, and cultivated, or in contrast, rejected, put aside, and forgotten; See Barbot, Tan, & Grigorenko, 2013).

The benefits of purposeful fulfillment could further extend to society such that having many people who are actively engaged in different creative outlets means even more potential for having positive, motivating influence from others. There will be a larger pool of people who would be receptive to creative ideas. This cascading effect could take place at the level of society and could have generational implications. The implementation of the *purposeful fulfillment of creative potential view* does have its limitations. For example, it could be a challenge to implement its principles with younger children and engaging in too many creative domains could prevent successful specialization in even one domain. The approach must also be empirically tested and shown to be an improvement over current practices used in schools to teach children how to be creative.

The purposeful fulfillment view is nonetheless promising. Having the mindset that you have considerable control over the fulfillment of your creative potential could be empowering, especially for children. It involves the realization that even seemingly trivial creative insights could be nurtured into something greater and it suggests the possibility of long-term commitments in multiple domains. It also entails being taught about the specific demands and constraints associated with particular domains, factors that have a direct influence on how creativity is expressed and how creative potential is ultimately fulfilled.

7.9 Summary

- A noteworthy creative contradiction in education is the misalignment between how we teach creativity to children and how creativity actually transpires in genuine contexts. This contradiction results from a limited understanding of how the creative potential of an individual is fulfilled.
- *The purposeful fulfillment of creative potential view* proposes that the fulfillment of creative potential:
  - is a long-term, perhaps even lifelong process
  - requires agency and active decision making
  - requires investment of personal resources
  - involves focused engagement with, and investment in, one or multiple creative outlets
- To facilitate successful fulfillment of creative potential, external agents—such as parents and teachers—should educate children about the process of purposeful fulfillment and emphasize children's agency in this process.
- Children must be taught the specific demands and constraints associated with the domain(s) with which they are engaging.
- Purposeful fulfillment of creative potential has both positive personal and societal implications.

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Chapter 8
Content Matters: Why Nurturing Creativity Is So Different in Different Domains

John Baer

Abstract Creativity brings joy, wonder, efficiency, excitement, and pleasure into our lives. Although creativity can also be malevolent (see, e.g., Cropley et al., Creat Res J 20(2):105–115, 2008), for the most part creativity makes life better, and most of us would like to have and to experience more of it. Nurturing creativity is therefore something that many of us would like to do. We'd like to help our students, our colleagues, our employees (or employers), and of course ourselves be more creative.

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And we can. Research has shown that many kinds of creativity training can be very successful. Scott, Leritz, and Mumford (2004) conducted a quantitative meta-analysis of creativity training research covering a half century of research on the effectiveness of creativity training. Their review included 70 published and peer-reviewed studies. They reported that "well-designed creativity training programs typically induce gains in performance" and that "more successful programs were likely to focus on development of cognitive skills and the heuristics involved in skill application, using realistic exercises appropriate to the domain at hand." (p. 361). Creativity training works, but note the last few words in the quote: "appropriate to the domain at hand." This, in fact, was their key finding. Creativity training worked when the training and the goals of the training (and the ways the effectiveness was tested) were *in the same domain*. "The most clear-cut finding to emerge in the

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overall analysis was that the use of domain-based performance exercises was positively related ($r = .31$, $\beta = .35$) to effect size" (p. 380).

Creativity training doesn't lead to an increase in creative performance across the board. It leads to increased creativity of the kind used in the training. If one wants to write more creative poems, one kind of training will work, but if one wants to build more creative structures, another kind of training will work. This effect was shown quite directly in a study (Baer, 1996) in which 157 middle school students had either taken part in a variety of divergent-thinking activities related to poetry-writing creativity, such as brainstorming words that could stand for other words or ideas (metaphor production) and brainstorming words with similar beginning sounds (alliteration) or had simply attended their regular English/language arts classes. The 157 students constituted the entire seventh-grade of a middle school, and the classes that had been randomly selected as the experimental group had the training during their language arts class time. A week later students in all the classes wrote poems and stories as part of their regular language arts class activities (the experimenter was not present and the activities were not linked to the training), and those poems and stories were later judged for creativity by groups of experts who did not know which students were in which group, using Amabile's consensual assessment technique (Amabile, 1982, 1983). The creativity training led to significantly more creative poems, but that same training did *not* lead students to write more creative stories, even though poetry-writing and story-writing are from the same larger domain of writing. This finding indicates that even within what might seem like a domain, smaller, more narrowly focused subdomain or task-specific effects may be quite different. This need for sub-domain specificity to properly gauge the effects of creativity training echoes what Pretz and McCollum (2014) cautioned about the need for extremely domain-specific analyses when looking at research results: "Perhaps prior studies of domain-specific creativity were not specific enough" (p. 233) to uncover effects that more specific assessments might have revealed.

Dow and Mayer (2004) considered another carefully targeted kind of creativity training: how to solve insight problems of different kinds. They addressed the issue of domain specificity/generality very directly:

> The purpose of this research was to investigate whether insight problem solving depends on domain-specific or domain-general problem-solving skills, that is, whether people think in terms of conceptually different types of insight problems. (p. 389)

Their motivation in conducting this research was the fact that creativity training has had a rather spotty record of success—perhaps from a failure to follow Pretz and McCollum's (2014) warning that "prior studies of domain-specific creativity were not specific enough" (p. 233):

> Training of creative problem solving has a somewhat disappointing history, because learning to solve one kind of problem rarely supports solving of other types of problems (Chase & Simon, 1973; Chi, 1978; Mayer, 1996, 2002; Ripple, 1999; Thorndike, 1906). (p. 397)

Dow and Mayer trained subjects to solve either verbal insight problems or spatial insight problems. Their training was successful: subjects receiving the training improved their skill in solving the kinds of insight problems on which they were trained. They then compared the effects of training on skill in solving the other kind of insight problems (i.e., how well did subjects trained to solve verbal insight problems solve spatial insight problems, and how well did subjects trained to solve spatial insight problems solve verbal insight problems). Their results were "consistent with the domain-specific theory of insight problem solving, namely, the idea that insight problems are not a unitary general category but rather should be thought of as a collection of distinct types of problems" (p. 397). There was no evidence of transfer: subjects' increased ability to solve one kind of insight problem (in comparison to untrained subjects) did not improve their abilities in solving other kinds of insight problems:

> What is learned when someone learns how to solve spatial insight problems? Our research suggests that students learn a general strategy that applies only to a subcategory of insight problems—that is, learning to overcome self-imposed constraints in solving spatial insight problems. We propose that insight problems should not be thought of as a unitary category of problems, but rather as a collection of distinct problem types. The distinguishing feature of each problem type is the general strategy that can be used to solve it. Consistent with theories of transfer based on specific transfer of general strategies (Mayer, 2002; Singley & Anderson, 1989), when one learns how to solve spatial insight problems one learns a general strategy that applies to other spatial insight problems but not to mathematical or verbal problems. What enables transfer is that the to-be-solved problem requires the same general solution strategy as a source problem that the learner already knows how to solve. (p. 391)

Not only does training in solving one kind of insight problem solving not transfer to other kinds of insight problem solving, but recent research argues that insight problem solving may have very little in common with real-world creative behavior. Beaty, Nusbaum, and Silvia (2014) looked at the correlations between success at solving two classic insight problems and real-world creative achievement and concluded that there was "no evidence for a relationship between insight problem solving behavior and creative behavior and achievement" (p. 287). Insight problem solving, they concluded, was a discrete domain of creativity that was unrelated to other kinds of creativity. Dow and Mayer's (2004) study showed that even within the domain of insight problem solving, further domain specificity was called for, in line with Pretz and McCollum's (2014) suggestion that micro-domain or task-specific analyses might be needed to ferret out the true impact of creativity training.

For those who have followed the debate about domain specificity and creativity, these findings should not be surprising. Although creativity was once generally thought of as a domain-general kind of trait—so that if a person was highly creative in one kind of activity it could be assumed that, other things being equal (such as access to the kinds of materials and specialized training that might be needed in some domains), that person would tend to be more creative, on average, than others in all or at least most activities—that view has undergone a radical shift. In the only Point-Counterpoint debate that the *Creativity Research Journal* has ever published (now almost two decades ago), the topic was domain specificity, and even the debater arguing for domain generality acknowledged at the outset that history had not been kind to his point of view:

> Recent observers of the theoretical (Csikszentmihalyi, 1988) and empirical (Gardner, 1993; Runco, 1989; Sternberg & Lubart, 1995) creativity literature could reasonably assume that the debate is settled in favor of content specificity. In fact, Baer (1994a, 1994b, 1994c) provided convincing evidence that creativity is not only content specific but is also task specific within content areas. (Plucker, 1998, p. 179)

This shift has been caused by an avalanche of research looking at actual creative performance (see Baer, 1998b, 2010, 2013, 2016 for summaries of this research) rather than such things as creativity test scores, which assume domain generality,[1] or self-assessment of creativity, which have serious validity problems—but even such self-assessments show evidence of domain specificity; see, e.g., Brown, 1989; Dollinger, Burke, & Gump, 2007; Kaufman, Evans, & Baer, 2010; Pretz & McCollum, 2014; Reiter-Palmon, Robinson, Kaufman, & Santo, 2012; Rowe, 1997; Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012).

The fact that creativity is very domain specific—and that being creativity in one domain tells us nothing about creativity in other, unrelated domains—does not mean that polymaths can't exist. In fact, domain specificity predicts the existence of polymaths. It just says they should be fairly rare. Zero correlations don't mean things cannot go together; lack of correlation simply means that there is no consistent pattern that links two variables. They may or may not co-occur, they just don't do so consistently. Guitar-playing skill, the ability to read Latin, height, and living in Ohio are (I assume) pretty much unrelated things. One would not assume because someone can play guitar well that she can (or cannot) read Latin, that she is either tall or short, or that she lives in any particular state. But that does not mean there are no tall guitar-playing Ohioans who can read Latin. Lack of correlation doesn't mean things can't go together, only that there is no reason to expect it. So it is for creativity in diverse domains. The fact that a person is a creative chef tells us nothing about that person's poetry-writing creativity, her mathematical creativity, or her engineering creativity, but that doesn't mean she cannot be highly creative in all four domains.

If we want to nurture creativity in diverse domains (such as the four just listed, cooking, poetry, engineering, and math), we can't simply nurture creativity in general and expect creativity in all domains to increase. Just as we can't teach

[1] It is interesting that when creativity tests do identify particular domains, even though claiming to be domain-general tests, they inadvertently offer strong evidence of domain specificity. The most widely used tests of creativity are the Torrance Tests of Creative Thinking (Kim, 2011a, 2011b, 2011c; Long, 2014; Torrance & Presbury, 1984), which come in two forms, verbal and figural. Both measure divergent thinking, but do so in different domains. (Divergent thinking is hypothesized to be a contributor to creative thinking, which is how a test of divergent thinking gets to call itself a test of creativity.) Torrance himself found that these two tests were almost completely orthogonal, correlating at the level of .06 (Cramond, Matthews-Morgan, Bandalos, & Zuo, 2005). This means there was almost no shared variance at all—or, put another way, that the two tests of creativity were measuring two discrete, unrelated skills.

domain-general content knowledge (it's hard to envision what that would be), we can't teach domain-general creative-thinking skills.

And creativity isn't the only kind of thinking skill that is domain specific. Without wading into arguments about general intelligence (*g*) and IQ testing,[2] consider the kinds of thinking skills that have come to be known as "higher-order" thinking skills, following Bloom's Taxonomy of the Cognitive Domain (Bloom, Englehart, Frost, Hill, & Krathwohl, 1956). I worked in a school long ago that had a "Higher-Order Thinking Skills Lab"—really, there was a room that had a sign that said that over the door!—where students were to be taught application, analysis, synthesis, and evaluation skills. The trouble was, that's impossible, at least as domain-general skills that can be applied and transferred across domains. Those skills are important, but what they mean, and the actual cognitive skills they require, vary by domain and task. There are no domain-general, decontextualized thinking skills, only domain- and content-specific thinking skills (2006; Baer, 1993; Kaufman & Baer, 2005; Owen et al., 2010; Redick et al., 2013; Thompson et al., 2013; Willingham, 2007, 2008).

Consider dissection, which is a kind of analysis. Being able to dissect a frog, dissect an argument, dissect a triangle, and dissect a villanelle are all wonderful skills, but they are unrelated skills that share a generic name and little else (and the fact that a student can do any one of these tells one nothing about her ability to do any of the others). Ditto for being able to synthesize chemicals, synthesize musical sounds, synthesize columns of data, or synthesize two philosophical arguments. Cognitive skills at the level discussed by Bloom are remarkably domain- and content-specific.

The appeal of domain-general conceptions of thinking skills (including creativity-relevant thinking skills) is obvious: teach one set of skills and students could use them everywhere. This is certainly the appeal of brain-training programs like Luminosity, Jungle Memory, and CogniFit (Day, 2013), even though there is no evidence supporting such cross-domain transfer (Katsnelson, 2010; Owen et al., 2010; Redick et al., 2013). As Owen et al summarized:

> 'Brain training', or the goal of improved cognitive function through the regular use of computerized tests, is a multimillion-pound industry, yet in our view scientific evidence to support its efficacy is lacking. Modest effects have been reported in some studies of older individuals and preschool children, and video-game players outperform non-players on some tests of visual attention. However, the widely held belief that commercially available computerized brain-training programs improve general cognitive function in the wider population in our opinion lacks empirical support. The central question is not whether performance on cognitive tests can be improved by training, but rather, whether those benefits transfer to other untrained tasks or lead to any general improvement in the level of cognitive functioning. . . Although improvements were observed in every one of the cognitive tasks that were trained, no evidence was found for transfer effects to untrained tasks, even when those tasks were cognitively closely related. (p. 775)

[2] There seems to be evidence that *g* and its metric, IQ scores, are related to performance in diverse domains (Neisser et al., 1996), but what those positive correlations mean is open to interpretation.

What does domain specificity mean for creativity training? Consider, by analogy, how one increases muscle strength. The kinds of exercises a body builder employs vary depending on the target muscles. Crunches will strengthen abdominal muscles but do little for biceps; if what one wants is big, Popeye-like biceps, crunches simply won't help much. (In contrast, for six-pack abs, crunches may be very effective, although I haven't personally tested this hypothesis.) And if one wants overall muscular strength, doing endless reps of the same exercise—whether one chooses crunches, pull-ups, curls, or some other exercise—is not the way to go. One needs to exercise all of one's muscle groups. One needs very muscle-group-specific exercises (recognizing that some exercises will involve more than a single muscle group, or course) to strengthen one's many muscles.

The idea that one could build muscular strength by focusing on only a single muscle and then expecting transfer is ludicrous. Equally foolish is the idea that one can exercise one's creativity thinking in a single domain and expect it to transfer to all other domains.

One more analogy: expertise. Expertise is very domain specific. To become an expert, one needs to study or work in a domain (usually for a rather long time, although that varies by domain), and there is little reason to expect that one's hard work acquiring expertise in a given domain will transfer readily to other domains. Everyone rightly values interdisciplinary thinking, but interdisciplinary thinking requires disciplinary knowledge in more than one domain. It does not mean thinking that ignores disciplines. One may sometimes be able to combine expertise in several domains to solve problems in an interdisciplinary way, but to do so one first needs disciplinary expertise. There is simply no such thing as domain-general expertise, and therefore no short-cut that would let one acquire expertise in all domains by learning expertise as a content-free, domain-general kind of cognitive skill (Baer in press).

That doesn't mean one cannot develop, employ, and strengthen expertise in multiple areas as part of a single interdisciplinary activity (which, as the name implies, will call on domain-specific knowledge or skill in more than one domain). To take the simplest kind of example, a math word problem will require both reading and math skills and may well help develop skills in both domains, but working on that word problem will probably have no impact on one's singing, mountain-climbing, or woodworking skills unless the problem directly involved one of those domains. It is possible to design activities that will call upon a wide range of skills and require content knowledge from diverse domains, but those skills and that content knowledge remain domain specific (just as salt and pepper are difference spices, even though one might use them together in the same recipe).

So how do we go about creativity training now that we understand the domain specificity of creativity? First and foremost, *content matters*. If creativity were domain general, then it wouldn't matter what kinds of creativity training exercises one did. That would be like having a single muscle that one could exercise and become strong in all ways. But research has shown us that this doesn't work and that domain-specific exercises are needed. Because creativity is domain specific, creativity training is like developing expertise, which must be done domain by domain (even though sometimes we can work on a few domains at the same time, as in the word problem example above), and like developing physical strength, which must be done muscle group by muscle group (even though some kinds of exercises might work on two or more muscle groups through a single activity). If one's interest is only on nurturing creativity in a single domain (as in the poetry-specific training study discussed above; Baer, 1996), then choosing all exercises from a single domain makes sense. If one's goal is to enhance creativity in many domains, however, then the content and focus of one's creativity-training exercises need to come from a wide variety of domains.

The most widely taught and practiced skill (actually a very diverse collection of skills) in creativity-training programs is divergent thinking, but divergent thinking is not a single thinking skill that one can simply call up like a computer-programming subroutine and use in any domain. The term "divergent thinking" describes many completely different thinking skills that only seem similar from the outside while on the inside (as cognitive processes) the various cognitively discrete and functionally unrelated skills may have little or no connection or overlap.

That doesn't mean the label "divergent thinking" is without value, just as the labels "red," "games," and "expertise" have value, even though the set of all things red, the set of all games, and the set of all kinds of expertise will each include an incredibly diverse collection of things or ideas. Consider the term "expertise," which can usefully describe a wide range of totally unrelated sets of skills and knowledge (such that expertise in red wines and expertise in accounting can both be described by the term "expertise" but have no overlapping content whatsoever—or at least I hope not when my accountant is doing my taxes). Similarly, the term "divergent thinking" can be used to lump together many totally unrelated sets of skills, each applicable only in its respective domain.

If divergent thinking were just one, domain-general skill, it would certainly make creativity training easier. Teach students that skill and they could apply it when working on any problem, no matter the discipline or content. But we know that's not how divergent thinking and creativity work. Thinking of unusual uses for a brick, unusual ways to decorate a theatrical set, and unusual metaphors for beauty are different kinds of thinking, just as the trapezius and the quadrilaterals are different muscles one might work to strengthen and red wines and accounting are different domains in which one might acquire expertise. Having a general concept called "divergent thinking" can be helpful because (like expertise) the general concept of divergent thinking may point us to some very domain-specific skills that we might want to develop in a particular domain to promote more creative thinking in that domain (as in the poetry-specific divergent-thinking training study discussed earlier). This is true even though the skills that constitute divergent thinking in one domain are most often completely different from the skills important for creativity in any other domain (and therefore require entirely different kinds of training, just as acquiring expertise in different domains requires different kinds of study or practice). But it's important to remember when we categorize things in this way that calling things by the same name does not make them the same.

So if one's goal is to improve divergent thinking in a single domain one should use exercises that relate to that one domain, but if one's goal—as is more common—is to nurture creativity in many domains, then the divergent-thinking exercises one uses must come from a wide range of domains.

Creativity training isn't limited to divergent-thinking training, of course, but the same kind of domain-specific thinking should guide any creativity-training program. Consider what we know about attitudes related to creativity. There is evidence that intrinsic motivation leads to higher levels of creativity than extrinsic motivation, which tends to both drive out intrinsic motivation and lessen creativity (Amabile, 1983, 1996).[3] Programs have been developed to inoculate students against the impact of extrinsic constraints or to increase their intrinsic motivation, with generally positive but also somewhat mixed results (Baer, 1997a; Baer & Kaufman, 2012; Cooper, Clasen, Silva-Jalonen, & Butler, 1999; Gerrard, Poteat, & Ironsmith, 1996; Hennessey, 1995; Hennessey & Zbikowski, 1993). But there is an inherent problem with such training, which could account for the rather mixed results. Like divergent thinking, intrinsic motivation is not a single, domain-general thing. It is a wide variety of totally unrelated things that have a single similarity (rather like the set of all things that include the color red). A person's level of interest in the field of anatomy, for example, tells us nothing about her interest in the fields of alchemy, algebra, aviation, or art, and the same personal satisfaction that might drive someone to create a beautiful work of art might not be at all motivating when it's time to solve an algebraic equation. What we call intrinsic motivation describes many completely different kinds of motivation, and one cannot build intrinsic motivation across the board, in a domain-general way. As with teaching divergent-thinking skills, one must build intrinsic motivation domain by domain.

Is there nothing that one can teach about creativity that is domain general? Assuming that there are some things, like divergent thinking and intrinsic motivation, that although varying by domain are nonetheless valuable in all domains,[4] then there is perhaps some value in sharing those insights. It might be useful to learn, for

[3] There is an on-going dispute about the impact of extrinsic motivators like rewards and anticipated evaluations on creativity (Baer, 1997b, 1998a; Conti, Collins, & Picariello, 2001; Eisenberger & Cameron, 1996; Eisenberger & Rhoades, 2001; Eisenberger & Shanock, 2003), and it is not yet clear how this dispute may be resolve. I have suggested elsewhere (e.g., Baer, 2016) that the contradictory data that has been produced may in fact result from a failure to take domain specificity into account (because extrinsic motivation may be detrimental in some domains and beneficial in others). For the purposes of this chapter, I am simply using intrinsic motivation as an example of how domain specificity should influence creativity training, regardless of the type of training (e.g., skill development, attitude change, knowledge acquisition, etc.).

[4] It is important to note that this is only an assumption. The impact of extrinsic constraints might vary by domains, as discussed in the previous footnote, and there may be domains in which divergent thinking promotes creativity and domains in which it does not. If this turns out to be the case for divergent thinking, it might help explain recent research that questions the power of brainstorming to enhance creativity (Diehl & Stroebe, 1991; Mullen, Johnson, & Salas, 1991; Nijstad, Stroebe, & Lodewijkx, 2003; Rickards, 1999). Different findings regarding brainstorming's impact may reflect domain-based differences, with divergent thinking being helpful in some domains but not helpful in others. This is an open question awaiting carefully designed research.

example, that in the early stages of idea generation is it helpful (a) to avoid thinking about how those ideas might be viewed by others (i.e., it might be wise to avoid imposing extrinsic motivation on one's self) and (b) to generate as many ideas as one can (i.e., it might be advantageous to try brainstorming or some other technique to promote divergent thinking). But neither of those is the same as working (c) to develop the skill of divergent thinking in a domain or (d) to nurture intrinsic motivation in a domain. The latter two approaches, like (almost) all of creativity training, need to be done on a domain-by-domain basis.

Creativity training can be fun, but to do creativity training well takes time and, sometimes, a lot of hard work. There are no quick, domain-general tricks, and even when done thoughtfully there is no guarantee that any kind of training will result in brilliantly creative ideas. Fortunately, the joy of thinking creatively (and of *sometimes* producing creative results!) are well worth both the time and the effort.

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Part II
Practical Applications & Promising Directions

Chapter 9
People, Passions, Problems: The Role of Creative Exemplars in Teaching for Creativity

Robert Root-Bernstein and Michele Root-Bernstein

Abstract The goal of educating for creativity must be active understanding rather than passive knowing. To understand is to have the capability to re-create, which trains the ability also to create. The ability to create requires problem-finding as well as problem-solving. It requires practice. Best practice involves the emulation of creative people and the variety of strategies they use to discover challenges and solve them. Certain contradictions, however, divide the classroom from "real-world" creativity: the emphasis on problem-solving rather than problem-raising, on objective expertise rather than subjective synthesis of skill and knowledge, on finding the solution rather than paths to multiple solutions. These contradictions may be overcome when curricula center on exemplary people who make a difference, on their passion for challenging problems, on the practices and processes with which they focus learning and invention. The more and more diverse models students learn to emulate, the greater their probability of making the leap from re-creating to creating for themselves.

9.1 Introduction: Contradictions in Contemporary Schooling

Some fifteen years ago, we were having a discussion with several of our best students, all physiology majors and seniors about to graduate college in a few weeks. The discussion revolved around the topic of insulin and its actions in controlling the body's blood glucose levels. On a whim, we asked the students whether they knew

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who had discovered insulin. None knew. We followed up by asking if any of the students knew how insulin had been discovered? In other words, supposing some cataclysmic disaster occurred and one could no longer obtain insulin from some pharmacy, could any of the students re-create its discovery and isolation? None could. So then we asked whether these students could tell us who discovered *anything* they had learned about in their classes or *how* the discovery had been made? Again, the answer was no.

Wow, we thought! What kind of education are we giving students that they end up knowing the names and functions of hundreds of biological molecules and their effects on various organ systems but can't name a single discoverer or discovery path? They memorize solutions to problems that no longer exist and the origins of which are not only unknown to them but not even imagined. They utilize information they have acquired passively without understanding how it came into being. They face a future in which there will be an inevitable need to recognize and solve new problems using new approaches that have yet to be invented, but have no knowledge of, let alone experience or practice with, the processes by which new problems are posed, new methods invented, or new principles imagined. What, in fact, have they really learned?

Educational systems must balance two conflicting goals: one is to transmit accumulated knowledge to students for future use; the other is to prepare students to create additional, new knowledge that the future will inevitably demand. The conflict arises from the fact that knowledge can be obtained by passive means while creating must be active. Creative people as diverse as the novelist Aldous Huxley and the engineer-inventor Charles Kettering called the first "knowing," the second "understanding." One can know something about something without truly understanding it in any meaningful way. We knew a man, for example, who read a book about the whys and wherefores of bike riding. Having completed the book, however, he was no more capable of riding a bicycle than before. He had book knowledge, we might say, but no personal experience or understanding of the phenomenon. Conversely, there are many people who can ride bikes but cannot explain how or why it is possible. This problem exists for both students and teachers in all subjects (Bamberger, 1991).

The ultimate goal of education should be, of course, to combine knowledge with understanding so that each informs the other. The best-educated individual is one who, metaphorically, can ride the bike *and* explain how it is possible. Such a person knows the theory, can enact its principles, and can explain and show another person how the two synergize. We have called this synergy of knowing and understanding "synosia," a term we derived from *gnosis*, the Greek word for knowledge, and from *synaesthesis*, a term meaning the synthesis of all senses and feelings. A synosic education is one in which formal knowledge and individualized understanding yield embodied comprehension (Root-Bernstein & Root-Bernstein, 1999).

How is such an educational scheme to be implemented? With reference, we suggest, to the best practices of the most knowledgeable and creative individuals of past and present. Many successful creators say the same thing: Learn to wield the skills necessary to create knowledge. Learn to solve problems, but also how to recognize and generate them in the first place. Learn to address problems in different ways from different angles. Learn that problems have many possible solutions. Focus on mastering principles, not facts. In other words, they say, learn not just what is already known, but the methods and means by which that knowledge has been constructed. Learn by re-creating the path a model creator has taken to problem recognition and problem solution. And through comparative re-creation, in which multiple solutions to the same problem or multiple problems are solved in related ways, absorb a broad set of strategies for learning and creating (Root-Bernstein, R.S., 1989).

9.2 The (Historical) Role of Role Models

As different as such an education may be from current curricula and current practice, it is not radical. Re-creation of problems and their solutions is precisely how many extraordinarily successful people have trained for centuries. In the seventeenth century, the polymathic philosopher-mathematician-scientist-inventor Gottfried Wilhelm von Leibniz argued that learning the methods utilized by previous great minds serves "to prosper the art of invention by disclosing method through illustrious example" (Truesdell, 1984, 586). The nineteenth-century French mathematicians Jules Drach and Everiste Galois similarly studied the ways in which their predecessors identified and solved their problems: "They desired to know as many different ways of inventing as possible" and so studied the "characteristic traits of the inventors" (Hadamard, 1945, 11). To do otherwise, as the twentieth century mathematician Jacques Hadamard wrote, is to come to know only one inventor – oneself (ibid.)

We find this same learning strategy serving creators in the arts. In the early 1400s the Italian painter Cennino Cennini advised young artists to "take pains and pleasure in constantly copying the best things which you can find done by the hand of great masters…take care to select…the one who has the greatest reputation. And, as you go on from day to day, it will be against nature if you do not get some grasp of his style and of his spirit" (cited in Leeds, 1984). In the 1870s, Manet, Degas, Cezanne, Morisot, Renoir and others in the revolutionary Impressionist group still favored learning directly from masterworks and their re-creation. At a time when some called for an end to the practice, these artists, as was said of Renoir, put themselves "to school again under the masters" (cited in Duro, 1988, 250). Many registered at the Louvre as copyists (Reff, 1964), where they were, in fact, "free to choose their own masters, could erase the traces of their one-sided [classical] education and find in the works of the past a guidance congenial to their own longings" (Rewald, 1973, 75). Picasso, one of the most influential artists of the twentieth century, also made copying at will an integral part of his artistic process (Galassi, 1996).

The same embrace of craft imitation characterizes the language arts. In *The Arte of Rhetorique*, the Elizabethan statesman and scholar Thomas Wilson argued that "by companiying with the wise, a man shall learne wisedome" (cited in Alexander, 2000, 7). In the nineteenth century Robert Louis Stevenson explained to the painter Birge Harnson that “the only way to become a master is to study the masters, take my word for it. It’s all one whether it’s in paint or clay or words.” He himself liked “to swallow a great master whole as it were, to read everything he’s written at one go, and then have a try myself at something in his manner” (cited in Terry, 1996, 78–79). In just this way Stevenson played “the sedulous ape” to a whole host of writers, filling a clothes-basket with his modelled efforts (Terry, 1996, 87). Twentieth-century novelist John Gardner also observed that it was “still instructive” to imitate old and unfamiliar masters of form. Close, line-by-line imitation “enables the writer to learn ‘from inside’ the secrets of some great writer’s style” (Gardner, 1991/1983, 142–143).

We have thus far drawn our examples from mathematical sciences and the arts in the Western tradition. Yet statistical studies of historical trends undertaken by Simonton (1975, 1978) suggest that learning from masters is a supra-disciplinary strategy that has served creators of all stripes well. Simonton’s data set consisted of 5000 eminent individuals living in Europe between the years 700 B.C. and A.D. 1839. As determined by citation in histories, anthologies and biographical dictionaries, these persons were creative in a wide array of fields, including the sciences, philosophy, literature, music, painting, sculpture, and architecture. A look at the time-wise incidence of their genius revealed that the number of eminent creators in one generation correlated highly with the number in the previous generation: “In other words, the more creative individuals available for emulation when a genius is in his or her developmental period [through age 30], the greater the increase in creative potential” (Simonton, 1978, 189). Simonton argues that the more role-models available for “possible imitation,” the earlier in life a potential creator may acquire creative skills and the sooner produce creative work, thus enhancing creative productivity and longevity.

Simonton’s point is well taken that access to “numerous role models” enhances creative development (1978, 193). Educational theorists speculate that the vigor of role-modelling and other forms of mentor relationships and apprenticeships largely reflects a learning that is situated in authentic experience (Collins, Brown, & Newman, 1989; Dennen, 2004; Enkenberg, 2001). One learns excellence in a métier by “becoming a practitioner, not [by] learning about practice” (cited in Dennen, 2004, 814). This holds true not only for traditional apprenticeship in craft or trade, typical of the pre-industrial world, but for cognitive apprenticeship in information-based, problem-solving expertise typical of the modern information age (Dennen, 2004, 813; Enkenberg, 2001, 502). In cognitive apprenticeship and related forms of problem-centered learning, the “temporal process of thinking” is demonstrated or modelled by the mentor or master and copied by the mentee or student. Tacit knowledge becomes “visible,” that is, available for imitation (Dennen, 2004, 814, 816).

Studies of informal learning among professionals speak to the enduring efficacy of role-model imitation in real-life situations. Among dentists, accountants, government employees, surveyors and religious personnel, Cheetham and Chivers (2001) found that training on the job includes different levels of “role-modelling,” from unconscious absorption of isolated skills or behaviors, to conscious imitation of individuals and their ways of doing things, to the internalization of mental traits and dispositions relevant to professional success (273, 282). Among novice geoscientists engaged in field training, situated learning or "guided apprenticeship" in the presence of mentors helps tie theoretical knowledge to the practical observation, collection, and analysis of raw data. In particular, guided apprenticeship in the field makes visible the processes by which the scientist transforms observations of nature into the words, signs, and symbols—the inscriptions—that capture and communicate knowledge (Kastens et al., 2009). Among artists in dance, theatre, music, visual arts, and language arts, mentors have been found not only to provide craft training, but to validate emotional and psychological aspects of art-making in support of creative outcomes (Bennetts, 2004).

The imitation of role-models and mentors in authentic learning environments (on the job training, fieldwork, art studios, etc.) goes, has always gone, hand in hand with the nurture of creative development and productivity. That said, the apprenticeship model appears difficult to implement wholesale in current primary, secondary, and college settings. Factors mitigating against such implementation include the lack of teacher-practitioners, especially in primary and secondary settings, and the high numbers of students per classroom. Nevertheless, there are ways in which the central tenet of role-model/apprenticeship learning can complement and enrich contemporary schooling. In the absence of living role models and mentors, teachers can direct students to copy exemplars of many other kinds.

9.3 Copying to Learn

To be an effective strategy, the use of copying in educational environments must be appropriate to learning targets and tasks. We begin, therefore, by categorizing the various ends for which copying may be a means. Note that we use the word copying in a general sense, to include both imitation and emulation, as defined by various researchers in the sciences and social sciences particularly interested in the mechanisms of social learning (e.g. Caldwell, Schillinger, Evans, & Hopper, 2012; Huber, 2007; Tomasello, 2004). We are sensitive to the distinctions between mimetic, behavioral imitation and open-ended, goal imitation (sometimes referred to as emulation) that have proven useful in ethological and developmental studies, but these do not capture the distinctions that are necessary for analyzing how various forms of copying are used pedagogically. We therefore essay some alternative approaches to copying that are appropriate to comparing its uses across different disciplines.

The most important aspects of creative thinking that can be copied revolve around products, problems, processes, people, and conditions. To imitate products is to consider—and consider deeply if copies are to be "true" – the materials used, but also the organizing aesthetics, the content or meaning, and/or the individual style of expression. To imitate problems is to explore intended goals and the skills and strategies necessary to their solution—to know when to employ materials, styles, skills and processes and to what ends. To imitate processes calls attention to

Table 9.1 Exemplars by aspects of creative thinking

Exemplars	Copy focus/Creative focus	Creative question
Products	Materials, physical/cognitive skills, styles, aesthetics, content	What?
Problems	Questions, goals	Why?
Processes	Strategies for making	How?
People	Behaviors, attitudes, emotional engagement	Who?
Conditions	Socio-economic factors	Where? When?

physical, cognitive and craft skills and strategies necessary both to navigate creative activity and to construct disciplinary products. To imitate persons is to model behaviors, attitudes, and emotional engagements that sustain creative activity. To imitate conditions for creativity is to recreate the environment or environments that best stimulate people to recognize problems and to emulate others who have utilized appropriate processes to produce innovative products. In short, it is possible to copy the "what," "why," "how," "who," "where," and "when" of creative thinking and, in doing so, learn different things from each approach (see Table 9.1).

Unfortunately, very little of the literature discussing imitation in disciplinary learning distinguishes clearly between different kinds of exemplars, types of copying, or copying purposes. This can lead to comparison difficulties across fields. Copying to learn can look quite different in visual art, writing, and the life sciences, principally because what is copied—product, problem or person—may differ task by task. While the drawing copy usually strives to "look like" the exemplary product as closely as possible, in terms of content, structure, and style, the writing copy invariably introduces new content into the mix. Then again, copying to develop basic skill in biology lab may involve the imitation and application of well-defined skills and procedures, yet introduce alternative materials or styles into the copied product.

Reproduction largely based on product differs from attempts by individuals to emulate problems or copy processes, which differ yet again from attempts to imitate the commitment of "creative heroes" and/or the conditions that best stimulated their creative enterprise. As the Nobel Prizewinner and General Electric research director Irving Langmuir once said, it is not possible to predict scientific discoveries (as these are inherently unexpected surprises), but it is possible to create environments in which they are more likely to happen (Halacy, 1967, 12–14). Thus, a good deal of the literature on innovation identifies social and economic, as well as psychological, factors stimulating discoveries and inventions in the past so that these may be emulated by persons and institutions today (e.g., Carlson & Wilmot 2006; Nayak & Ketteringham, 1986; Roberts, Levy, Finkelstein, Moskowitz, & Sondik, 1981; Simonton, 1978). Far from generating a close copy of prior products, the explicit purpose of problem-, process-, people-, and condition-emulation is more often explicitly to generate effective novelty, whether at a personal or professional level.

Beyond the question of whether one is copying a product, problem, process, person, or condition (or some combination thereof), additional complications confuse the question of what copy method best suits the task at hand. While it is possible to memorize a mathematical proof or recite a poem and obtain an "A" grade for verbatim reproduction, this is a completely different thing than, say, learning to play a song by ear; and both of these are dissimilar to copying a painter's style or a writer's plot structure.

On the one hand, memorizing a mathematical proof requires no learning beyond immediate content. The student does not learn how to invent the proof for herself nor does she have to think about what strategies the mathematician chose to devise the proof, nor whether there might be other ways to arrive at the same answer. Such a student may, in fact, develop no mathematical skills whatsoever, other than the operational ones required to plug values into appointed slots. On the other hand, copying another's performance of a song necessarily involves more active engagement on the part of the learner. The novice musician cannot reproduce a memorized song without also developing motor and musical skills necessary to play or sing it. The result is what might be called a "faithful" copy—just as much an imitation of the original as is the memorized proof or poem, but the musician has at least added to it a kit of refined skills and new techniques.

Both **mimetic copying** and **faithful copying** differ yet again from the kind of copying that reproduces a model's set of aesthetic rules or borrows its formal structure or transposes a salient feature as points of departure for otherwise original development. Writing practice that facilitates development of craft is less likely to mimic or memorize than it is to "copy-change," to borrow or adapt the structure, style, and/or aesthetic of a past master to new content (Dierking, 2002). We call these multiple, yet related purposes **adaptive copying**. These latter challenges require the creator to understand the principles of his or her field and how these can be applied to particular materials to yield a particular type of result, though the result may be unique.

An even more powerful kind of copying involves the re-creation or re-discovery of results (whether of content, method, style, or principles) previously derived by the model creator. In what Cain (2010a, 2010b) has termed "enactive copying"—and we call **re-creative copying—**the copier or re-creator finds his or her own path to the desired end and in so doing recapitulates the creative process of the original creator. When multiple models are re-created and compared over time in **comparative re-creative copying**, the student learns a variety of approaches to problem-solving, the strengths and limitations of each, and an understanding of how, why, and when to apply different strategies effectively (See Table 9.2).

As Table 9.2 suggests, utilizing increasingly sophisticated types of copying can involve cumulative practice and mastery of skills, techniques, understandings, attitudes, approaches, and strategies that link imitation and emulation to creative endeavor and outcome. Recognition of this trajectory can have impact in the classroom, as is becoming increasingly clear, at least in arts training. Among a handful of artist-educators who, over the last 15 years, have investigated or utilized imitation as a means of learning, there is agreement that mimetic and faithful copying promote the development of craft skill, disciplinary knowledge, and critical and analytical ability as well. In a study of the informal learning processes of popular

Table 9.2 Classification of copying type or method by learning goals

	Copying type or method				
What may be learned aka benefits	Mimetic copying	Faithful copying	Adaptive copying	Re-Creative copying	Comparative re-creative copying
Knowledge content	X	X	X	X	X
Skills, physical & cognitive	X	X	X	X	X
Material properties	X	X	X	X	X
Methods/techniques		X	X	X	X
Formal structures		X	X	X	X
Aesthetic means/ends			X	X	X
Questioning/problem generation			X	X	X
Creative attitude & engagement			X	X	X
Constraint change				X	X
Creative strategies				X	X
Alternative approaches					X

musicians, Green (2002), for one, found that by imitating music "by ear," self-taught musicians picked up intuitive understanding of chords, harmonic progressions, song structure, and style—all by dint of purposeful listening, imitating, and re-listening/self-correcting (2002, 61, 73).

In the language arts, Dierking (2002) found that engaging students in the simplest forms of copying, at the interstices of faithful and adaptive copying, eased students into the making of poems and stories. Alexander (2000) similarly found that an imitative method of teaching writing, in which students studied an exemplary passage of writing and then copied its style in a piece of their own, built language skills, literary appreciation, and creative confidence. In the theater arts, McKinnon (2011) also included among the benefits of this kind of copying the development of critical and creative skills. In and out of the classroom, he argued for "creativity as a function of adaptation, rather than of originality" (McKinnon, 2011, 56). Creative breakthroughs, for students as well for professional playwrights, are more often than not the direct result of adaptation of past form, and the recombination of borrowed ideas, characters, and plots. We've argued much the same for developing haiku craft (Root-Bernstein, M., 2017). Green, too, found that the adaptive copy serves as "a precursor to original invention." At heart, she asserts, "originality is born of imitation…" (Green, 2002, 75; see also Harnad, 2007, 130).

In their controlled studies of student response to adaptive copying in the visual arts, Ishibashi and Okada, (2004, 2006, 2010), demonstrate that choice of exemplar plays a critical role in the learning outcomes of faithful and adaptive copying. Copying from a single or previously known model can "constrain the problem search space" (2006, 1545), but when confronted with an additional, "incomprehensible" (i.e. novel) model, student work opens up to new ideas and solution possibilities. In other words, old aesthetic constraints relax and new aesthetic ideas and solution possibilities present for exploration and use. Cain argues in the same vein that "copying works because it suspends our habitual drawing practices and dislodges our usual modes of thinking" (2010a, 253). In fact, re-creating a model "constraint… creates opportunity" (260).

The essence of that opportunity is clearly articulated in Cain's tour de force exploration of re-creative imitation. As an advanced student in the visual arts, she copied a drawing by her study subject, the artist Richard Talbot, in order to ferret out the artistic problems and creative processes that shaped his work. Like Ishibashi and Okada, Cain realized that imitation, as a re-creative process, allowed her to figure out the intention of the original creator and take on that intention as a secondary creator. She then applied this problem understanding to a set of drawings of her own, working out an artistic challenge of her choice in his manner. The result, for the artist-scholar, was two-fold, involving a personal development in technical skill, problem generation, and aesthetic understanding and a cogent rationale for a copying pedagogy, what she calls "a method of enactive copying" (Cain, 2010a, 252). Comparative re-creative copying, which introduces multiple sets of problem-solving techniques and processes simply enlarges the learner's inventive toolkit.

Importantly, studies of social learning and its neurological basis articulate many of the benefits of copying reviewed here. In an examination of physical imitation among children, Wohlschäger and Bekkering (2002) argue that copying model actions builds skills. More to the point, it builds understanding of the modeled behavior, for imitation, especially among children, tends to be inaccurate in the details, though accurate in the end result. Children primarily imitate the goal of a model's actions and pay less attention to the course of movement. In order to copy, they must engage in understanding purpose and intent. For Wohlschäger and Bekkering the de-coupling of ends from means introduces variation and development into the process of copying. "[A] goal-directed theory of imitation," they write, "gives room to creativity in imitation, because the way the goal is achieved is left to the imitator…" (2002, 111). Moreover, "[t]his type of creativity probably plays a very important role in the evolution of culture and technique" as imitators influence one another. Recent computer modeling of imitative behavior among competitive agents also argues that "copying is typically imperfect and errors in imitating a behavior at times yielded improvements" (Pennisi, 2010, 167). Copying to learn facilitates learning to create.

The positive observations of practitioners, teachers, and social scientists notwithstanding, we must acknowledge a large literature, too vast to consider here, that weighs in on the "bad" of copying (for example, Victor Lowenfeld, as discussed by Kozlowski & Yakel, 1980; Wilson, 1983; Youngblood, 1982.) Suffice it to say, copying can be (and has been) properly used or abjectly abused; some disciplines, such as the visual arts, have swung from slavish devotion to near complete banishment of the learning method (Cain, 2010a, 2010b; Kozlowski & Yakel, 1980; Leeds, 1984; Simpson, 1943; Wilson, 1983; Youngblood, 1982). It appears to be the case, nevertheless, that learning to create is impaired when we never copy and when we only copy; when no copying forestalls the development of physical and analytical skill; when copying becomes an end in itself, focused on mimetic reproduction of product at the expense of process. Somewhere in the middle of this pedagogical tension, classroom teaching can balance copying with creating and can purposefully target, too, a whole gamut of educational goals from skill development to creative problem finding to creative process and outcome.

9.4 Learning to Pose Problems and Identify Challenges

We turn now to additional, if related, contradictions or tensions that divide the classroom from "real-world" creativity: the emphasis on problem-solving rather than problem-finding, on objective expertise rather than subjective synthesis of skill and knowledge, on finding the solution rather than paths to multiple solutions.

One of the most important aspects of the creative process that can be learned by re-creating the work of eminent predecessors or by emulating their cognitive strategies and disciplinary purposes is problem posing and effective challenge identification. Sir James Black, the Nobel Prizewinning pharmacologist who invented two of the most important classes of drugs now used to treat heart disease and stomach ulcers, provides an excellent example. One of his favorite strategies for making discoveries was to take a well-known, persistent problem and turn it upside down or inside out. His first major discovery involved cardiac insufficiency. At the time Black began his work, it was recognized that cardiac insufficiency resulted when the heart obtained too little oxygen to pump as strongly as it should. The way the problem was usually stated led researchers to try to develop drugs that would *increase* blood flow (and thus oxygen) to the heart. As Black quickly realized, however, any drug that increased blood flow to the heart also required the heart to work harder and, consequently, to need even more oxygen. The most obvious approach was an unwinnable game that too often led to heart attacks rather than cures.

Black decided to state the problem differently: might there be a way to *decrease* the amount of oxygen the heart needed? Stating the problem in this new way inspired him to look for a drug that lowered the use of energy by the heart. While most of his colleagues thought this new approach was crazy, Black's development of what are called "beta blockers," which do decrease the heart's need for oxygen, have been a huge boon to cardiac care (Wolpert & Richards, 1997, 123–129). The lesson is simple: many innovators are successful because they, like Black, reformulate their questions by challenging widely held assumptions. Innovators understand that the way a problem is posed either limits or expands possibilities for solution.

We put particular emphasis on problem posing for several reasons. First, problem posing is a skill that often differentiates the most creative people from their less creative peers. Second, this skill forces the learner to apply what he or she knows to new situations. And finally, the ability to pose answerable questions—indeed, how to question in general—is too often ignored. As Czikszentmihaly (1994) has written with regard to his study of problem finding, "creative individuals have pointed out in their work that the formulation of a problem is more important than its solution and that real advances in science and in art tend to come when new questions are asked or old problems are viewed from a new angle . . . yet when measuring thinking processes, psychologists usually rely on problem solution, rather than problem formulation, as an index of creativity. . . They thus fail to deal with one of the most interesting characteristics of the creative process, namely, the ability to define the nature of the problem" (138). (See also Dillon, 1982.)

What goes for psychologists also goes for educators, who generally focus on problem solving to the complete exclusion of problem-posing skills. Lewis, Petrina and Hill (1998) have put it this way with regard to technology education: "Problem posing, or problem finding… is a neglected aspect of our field within which inheres boundless opportunity for fostering technology-inspired creativity in children. How technologists come to problems, and how they reformulate them in their quest for solution is as important for children to understand as how they ultimately solve these problems" (n. p.). LaBanca concurs: "Problem finding exists more often as a theoretical construct, rather than an empirically studied concept and is infrequently associated with science education" (2008, 1). One could easily say something similar about all other fields in the core curriculum—when it comes to problem posing, contemporary schooling is pedagogically challenged.

Nonetheless, learning how to pose problems, like learning to copy, benefits learning to create. In contrast to a knowledge-accumulation form of learning, which limits the student to the confines of the teacher's knowledge, a problem-posing education encourages students to construct their own understanding of the world, limited only by their own sense of what is possible (Friere, 1970; Gregson, 1994; Wallerstein, 1987). Take, for instance, the many studies demonstrating that in mathematics the standard problem-solving approach discourages students who find mathematical abstractions opaque. If students are actively encouraged to question a problem, however, they begin to identify and clarify appropriate steps towards solution. The result is improved attitudes and motivations for learning as well as better content mastery (Akay & Boz, 2010; Brown & Walter, 1993; English, 1997; Silver, Mamona-Downs, Leung, & Kenney 1996).

By way of example, consider the following math task: write an equation describing how to calculate how many matches must be played in an elimination competition among 963 tennis players. The problem-solving approach is to set about laboriously calculating the given information: 963 players, 2 players to a match, means how many initial matches? From these initial matches, half the players will survive to play another round, meaning how many more matches; etc. etc. Once a solution is achieved, it must be transcribed into mathematical signs and symbols and then tested against other cases. Many students will balk at the work involved. But if the learner is encouraged to ask questions about the problem first, the way forward simplifies. Someone might ask, "What do we know about the person who wins the tournament?" Someone else might answer, "She or he is the only one who doesn't lose a match." Which might provoke further clarification: "So that means that everyone else in the tournament has lost a match, right?" And someone else might clarify, "Just one match each?" To which the answer is, "Yes, every player except the winner loses one match each." And suddenly, the answer to the problem—the equation—emerges without any real calculation at all. The number of matches that must be played, M, is the number of players in the tournament, P, minus 1 (the winner who never loses), or $M = P - 1$. Questioning the problem allows for its re-posing, which in turn brings to light an intuitive solution, à la Sir James Black.

Just as there are different types of copying, there are different ways of questioning problems. Tracy (2005) provides a useful taxonomy, categorizing the questioning of problems by purpose: (1) clarification, (2) elimination, (3) exploration, and (4) lacunae identification (spotting gaps in knowledge). **Clarification** investigates and illuminates the sub-problems within any interesting and important problem, as in the tennis-match math task discussed above. **Elimination** analyzes problems in terms of whether they are solvable given the constraints of time, money, available materials, or acceptable outcomes (e.g., we could stop global warming by creating a nuclear winter – but should we?). **Exploration** generates new problems as a result of solutions to initial sub-problems. Lewis et al. (1998) provide the following example: "Once it was determined that the Hubble telescope was out of focus, a second layer of problems emerged, having to do with how to re-focus the telescope. That solved, the problem became how to install the new modification. There were opportunities for posing problems all along the way" (n.p.). And finally, **lacunae identification** directs attention to holes in problem understanding—regarding AIDS, for instance, our "knowledge" that HIV plays a causal role has not produced a cure, so we clearly do not know as much as we need to know. One can argue that the solution will only emerge when we understand clearly the nature of our ignorance.

With this in mind, efforts to encourage the recognition of ignorance through the practice of focused questioning fill a substantial lacuna in contemporary pedagogy. The "curriculum on medical ignorance," devised by Drs. Charles and Marlys Witte and philosopher Ann Kerwin, purposefully categorizes ignorance in terms of the things we know we don't know (explicit ignorance), the things we don't know we don't know (hidden ignorance), the things we think we know but we don't (false knowledge or misknowns), and the things we think we don't know but we do (false ignorance) (Witte, Kerwin, & Witte, 1988; Witte, Kerwin, Witte, and Scadron 1989; Witte, Witte, and Kerwin 1994). **Explicit ignorance** consists of the problems and challenges that we formally address in our research in or across disciplines. **Hidden ignorance** is the sort that one encounters only as a result of serendipity (the "control" in an experiment produces a significant result while the test variable does not) or when a solution to one problem creates a new and unexpected sub-problem (as when a solution to the Hubble telescope flaw raises the problem of how to implement it). **False knowledge** is the sort that Black addressed when he challenged the belief that the heart needed more oxygen. **False ignorance** stems from a refusal to accept a source of knowledge, as when a physician might reflexively reject a (perfectly effective) home remedy as superstition. In addition, there are **taboo questions** and **unanswerable questions** that intrude on deeply ingrained beliefs and attitudes or philosophical/political issues concerning the validation of knowledge content and expertise in a discipline.

By and large, when one looks at standard curricula in most disciplines, none of the five types of ignorance identified by the Wittes and Kerwin are addressed. We do not challenge students to identify false knowledge, false ignorance, hidden ignorance, and taboo questions or even to tackle explicit ignorance. Essentially every question that *is* posed within standardized curricula is of a sixth type, which one might call "personal ignorance": facts and figures that the student does not yet know, but the teacher does. When the other five types of ignorance are addressed, however, it quickly becomes evident that there are no experts in the fields of the unknown (Root-Bernstein, R.S., 1989, 2008). Teachers give up their role as "sage on the stage" and become "guides to the side" facilitating exploration. Questioning becomes a student-centered method for acquiring understanding rather than a teacher-directed method ascertaining knowledge acquisition.

As with kinds of exemplars and types of copying, problem-questioning purposes and kinds of ignorance combine in complex ways and yet, at the same time, break down into teachable units (Root-Bernstein, R.S., 1982, 1989, 2003) (See Table 9.3). Categories of problem questioning—whether for clarification, elimination, exploration, or lacunae identification—can help direct attention to the kinds of ignorance that hold back student learning and the construction of knowledge. For example, questioning for problem lacunae can be applied in two distinct ways to hidden ignorance. One is to ask whether we know enough about what to expect of a system to recognize whether there are hidden pockets of ignorance at the heart of our challenge. Alternatively, one can ask how to reveal and address hidden ignorance, for instance in a scientist's laboratory results. What criteria might define anomalies and other unanticipated factors at work in her experiments? Similarly, questioning for problem clarification often consists precisely of determining which of the six types of ignorance one is dealing with so that the appropriate methods can be employed in problem solution.

A key pedagogical point here is to realize that different types of ignorance call on different problem-posing strategies. As the tennis match challenge suggests, one common method utilized by successful innovators tackling explicit ignorance is a process of reformulating the problem statement as it is originally posed. Yet another common strategy used by innovators addressing a persistent problem that seems resistant to solution is to turn the problem statement on its head: assert that the assumptions are incorrect and replace them with their contradictions. An example of this strategy was given above with regard to Black's approach to heart disease.

Another strategy for addressing explicit ignorance, when it becomes clear that a solution is possible but very difficult to achieve, is to ask, "How would I attack this problem if I were lazy?" The Nobel Prizewinner I. I. Rabi, for example, did a quick calculation of how long it would take him to complete his doctoral research if he used the method then available and found out it would take him decades. Faced with the question of elimination, Rabi chose to retain the problem and eliminate the conventional procedure. Instead, he gave himself six weeks to determine if there was some other approach that would save time. Clarifying the problem, he found a method that permitted him to complete the research in a few months (Bernstein, 1978, 52–55).

To recognize false knowledge resulting from answers we think we have achieved but are not in fact correct requires constant re-evaluation. Charles "Boss" Kettering, who led research at General Motors in the 1930s, once recalled the following exam-

Table 9.3 Problem-questioning purposes may address different types of ignorance and utilize different strategies

Type of problem question	Explicit ignorance	Hidden ignorance	False knowledge	False ignorance (hidden knowledge)	Taboo questions	Un-answerable questions	Personal ignorance
Clarification	Strategy: Reformulate problem; Turn problem on its head	Strategy: Consider observations and anomalies ignored by others	Strategy: Reevaluate prior failures; Question successes; Delay closure	Strategy: Use hidden ignorance methods	Strategy: Ask anyway! Determine cause of taboo	Strategy: Challenge validity of question	Strategy: Break into sub-problems; clarify assumptions
Elimination	Strategy: Evaluate implications of solutions; What if I were lazy; Turn to new problem	Strategy: Consider whether current approach is sufficiently complete, meets expectations	Strategy: Validate knowledge in question	Strategy: Test extra-disciplinary knowledge claims	Strategy: Transform into acceptable questions	Strategy: Demonstrate logical fallacy or untenable assumption	Strategy: Gain knowledge necessary to answer question; evaluate possible answers
Exploration	Strategy: Question assumptions; Focus on next generation problems	Strategy: Run controls; Extrapolate excessively; Push beyond boundaries	Strategy: Consider alternative solutions; Challenge assumptions	Strategy: Search for extra-disciplinary claims of knowledge	Strategy: All of the exploration strategies to the left	Strategy: Consider implications if answerable; reformulate to be answerable	Strategy: Embrace ignorance; Use it to fuel curiosity; Ask questions!
Lacunae Identification	Strategy: Break into sub-problems; question assumptions	Strategy: All of the above!	Strategy: Find anomalies and limits of existing knowledge	Strategy: Who *should* know this if the experts don't?	Strategy: All of the exploration strategies to the left	Strategy: Identify missing elements in question formulation	Strategy: Identify what kind of ignorance you have (see rest of chart!)

ple. Early attempts to build a workable diesel engine at the turn of the 20th century failed. Investigation at the time had pinpointed leaky pistons resulting from the inability to machine the tight fit of components. No solution was then possible. Twenty-five years later, however, new precision-machining techniques were available to take care of the leaks and under his watch, starting in the 1930s, diesel engines revolutionized both train and truck transportation. As Kettering saw it, “If we had taken the results of past experience without questioning the reason for the first failure, we would never have had the present light-weight, high-speed Diesel engine…” (1935, 2) No surprise, he recommended a constant re-evaluation of prior failures in light of new developments to correct for premature elimination.

The point, for Kettering, was to define problems accurately but also to leave them open to reexamination even when they appear solved. Getzels and Czikszentmihalyi (1976) found delaying closure in the arts also increased the probability of achieving unusually creative outcomes. Indeed, many innovators ask whether there are other ways to go about reaching an important solution than that by which it has already been achieved. This “alternative solution strategy” has the advantage of providing the learner/creator with multiple and novel challenges framed by a clear end point. This is a strategy that many of the most creative scientists have utilized, including Albert Einstein, Richard Feynman, and Linus Pauling—all of them Nobel Prizewinners (Root-Bernstein, R.S., 1989). They realized that the more ways that they learned to achieve a particular answer, the more connections they created among the things that they knew, thereby achieving much deeper understanding. They also found that the first answer was not always the best or the most revealing solution. Indeed, every answer presented a new opportunity for knowledge synthesis.

To discover things that we think we don’t know but we do (hidden knowledge) yet other strategies must be brought into play. First, we must bear in mind that there are no experts in ignorance. If a problem persists, then its persistence proves that the experts do not have the answers. One must then ask whether there are non-experts who claim to have solutions. Such claims are themselves problematic simply because they lie outside of the domains of validated knowledge. Can these claims be tested so as to convince skeptics? If the claims challenge accepted principles or assumptions of the discipline (i.e., also fall into the “taboo question” category), do they survive scrutiny? In most of these cases, the questioner must be referred to sources and role models that are outside of the bounds that define disciplinary expertise. Looking to unusual sources of information, however, raises yet another set of problems involving how to evaluate knowledge that has not been formally integrated into the canon of accepted wisdom.

Finally, there is the question of whether the right problem has been posed or the right challenge identified. Too many people follow the crowd when it comes to finding problems and challenges, resulting in often useless or even wasteful competition to achieve the first or best solution. Some innovators sidestep the “me, too” syndrome and assume instead that any problem or challenge attracting sufficient attention will eventually be solved. They then ask themselves what new problems or challenges will attend that eventual success. In other words, when we solve the challenge everyone has focused on now, what opportunities will open up that no one is thinking about yet? Pondering the next generation set of problems and challenges before anyone else gives the innovator an obvious leg up.

To return now to our opening theme of role-modelling, one of the most interesting challenges that students can be given with regard to problem posing is to compile and share a list of problem-posing strategies as used by model individuals. First and most simply the challenge is to look for those strategies that work within a given discipline, and then, at a more complex level, to categorize them according to how generally they can be applied across disciplines. Happily, not only do many biographies and autobiographies of successful people contain such process exemplars, but there are an ever-increasing number of books about problem-posing, ignorance curricula, "nepistemology" (how ignorance comes into being), and "agnotology" (the study of ignorance) being published each year (e.g., Brown & Walter, 1993; Firestine, 2012; Getzels & Csikszentmihalyi, 1976; Gross & McGoey, 2015; Holmes, 2015b; Proctor & Schiebinger, 2008). This search for people and process exemplars will reveal dozens of unsolved questions and still-hazy possibilities that exist within and across fields. Students inevitably recognize how little we actually know and, conversely, how much there is yet to discover and invent—a strong stimulant to curiosity and the drive to discover. Such "ignorance exercises" encourage shared learning within the classroom as well as the self-learning habits that motivate individual creative endeavor across a lifetime.

In his examination of the case for teaching ignorance, Holmes (2015a) concludes that "[t]he time has come to 'view ignorance as "regular" rather than deviant,' [as] the sociologists Matthias Gross and Linsey McGoey have boldly argued. Our students will be more curious — and more intelligently so — if, in addition to facts, they were equipped with theories of ignorance as well as theories of knowledge" (A21). It is the point of this paper to concur. Transmitting to our students what we all know permits us to build upon our collective experience, but transmitting as well what we do *not* know, in combination with how we may formulate our ignorance in addressable ways, spurs the further development of understanding.

9.5 Educating Through People, Problems and Passion

At last we reach the final and most important task of education, to instill in students a passion for learning that lasts a lifetime. There is little doubt that transformations in our sciences, technologies, arts, and cultures will continue unabated into the foreseeable future and that with these changes any information that we can provide our students will almost immediately be outdated. The only solution, as virtually everyone in education realizes at some level, is to train life-long learners. Yet when we look at most curricula, they are still focused on transmission of knowledge rather than understanding.

History, for example, is not taught as a series of questions about how we may use our knowledge of the past to understand the present, or even how to ask that question in answerable terms, but rather as a set of narratives and facts about what happened. Science is not presented as a method for challenging ignorance but, again, as sets of facts about what we think we know. In consequence, our students too often tell us that while they "like" a subject, they can't imagine pursuing it. All the important things in science and technology have been discovered or invented. There is nothing more that can be known about history. Even painting and music are dead, all possible forms already explored. Sorry to say, this is the impression most students have of most subjects. Our pedagogical failure—to distinguish between knowledge and understanding, to teach where both shade off into ignorance and opportunity—directly results in a closure of the student mind.

How to explain this premature closure more precisely? Let's analyze, for a start, how most science education is purveyed in light of our taxonomies of copying and some answers become self-evident. College students are generally introduced to science through large lecture formats in which content is presented in a form amenable to memorization. That is to say, content is stripped of all people; the problems that generated the discoveries are rarely if ever mentioned; the idiosyncratic paths the discoverers and inventors took to their innovations are excised; the context in which the work was done is never considered. In other words, science students are generally limited to learning—and copying—the "what" of science, with little or no encouragement to investigate the "why," "who," "how," or "when and where."

In addition to the memorization of information, the nature of any additional copying that is performed is also rudimentary. In lecture courses, learning is generally limited to recreating solutions to problems that have already been solved using techniques provided in class. Students do not invent their own problems or challenges, re-invent methods for solving them, or get credit for recognizing new paths to solutions. In fact, it is usually the case that their solutions must be not only similar to each other but identical, reached by the same paths of reasoning. In other words, the nature of copying to learn rarely rises above the purely mimetic or faithful levels.

The situation grows dire in most science laboratory courses, where the purpose of performing experiments is rarely made clear to students and, in many cases, is not clear in the minds of teachers, either. Most science laboratory exercises consist of recreating a famous scientific experiment such as Galileo's experiments with falling bodies, the synthesis of some chemical, or the isolation of DNA from some plant or animal. Unfortunately, these "exercises" tend to be mimetic as well, stripped of context (including why anyone would want to perform such an experiment in the first place) and of pedagogical goals. Only in the rarest cases have we seen lab exercises clearly state that their goal is, for example, to develop a specific set of manipulative, observational, or measurement skills; to generate data to explore the probabilistic distribution of observations under real-life conditions; or to uncover inaccurate student preconceptions about nature. Ask most students – even the best – why they did any particular laboratory exercise and what they learned from it and most will be hard-pressed to tell you. And that's because these laboratories utilize the simpler forms of copying, rather than its more sophisticated types and methods or purposes and outcomes.

Similar problems harm the teaching of other subjects as well. History is almost always taught through the college level without any sense of how “facts” are generated or explanations of events developed. More often than not, the arts utilize the lowest levels of mimetic and faithful copying or, worse, none at all. In the latter case, an unbalanced emphasis on personal originality and the search for novelty, at the expense of training in past traditions, means that students have little opportunity to build a full repertoire of craft skills or move beyond the recapitulation of old artistic ideas (Cain, 2010b; Kozlowski & Yakel, 1980; Leeds, 1984; Simpson, 1943). Ultimately, pedagogical models that do not adequately recognize the powers of copying to learn and to create do not empower students to direct their own autodidactic efforts competently or to think for themselves within or at the forefront of disciplinary contexts.

At this point, we may begin to understand why so many of our students know a great deal but understand so little. Beyond critique, what can be done about it in the classroom? Historically, what has worked for learners and creators across many disciplines is to find inspiring role-models, re-create the role-model’s problems and challenges, and re-invent their methods and solutions. Sometimes this re-creational methodology has been implemented through actual apprenticeship with living individuals; sometimes through time or space by re-imagining the products, processes, and problems of a person long dead or beyond reach. Infuse day-to-day classroom teaching in the same way with people, passions, and problems, we argue, and potential solutions to the premature shut-down of understanding and life-long learning become manifest. Such was our thinking, at least, when we first realized that our students knew a great deal of physiology but understood practically none of it. We subsequently offered a new capstone course to graduating seniors in which each student chose an important discovery in physiology and recreated it as far as possible without actually having access to a laboratory.

In essence, this task engaged the student in a semester’s worth of direct re-creative copying, (similar to shorter-term “design heroes” assignments such as Dowlen (2003) has described for engineering students). First, each student had to figure out how the exemplary discoverer identified and defined the problem(s) motivating research. In so doing, many students discovered many of the points we have made here: for example, that a key to doing great scientific work is to define problems differently than one’s colleagues. Second, each student had to explain how and why the exemplary discoverer used the particular methods and tools that they chose to address their problem. At this point, students often realized that exemplary discoverers had often been trained outside of the field in which they made their discovery, and that this extra-disciplinary importation of new or different tools enabled them to solve the problem at hand before anyone else. Third, each student had to explain the various trials and errors experienced by the exemplar and how he or she recognized that some tantalizing leads were, in fact, dead ends on the road to discovery. Fourth and finally, each student had to address the response of the broader scientific community to the exemplar’s discovery, more often than not finding that competitors were skeptical and sometimes outright defamatory.

Students engaged as well in a semester's worth of indirect comparative re-creative copying. Each student not only wrote a lengthy paper describing the methods and means by which their exemplary discoverer succeeded, but also presented a 30-min version of their work as a lecture to the rest of the class. In this way, every student personally mastered the path to one discovery and learned to compare and contrast it with discovery paths studied by their classmates. In short, they learned about these discoveries—the facts—within a broader context of the people, problems, processes, and passions that made the discovery happen. The students both knew *and* understood. Indeed, their understanding manifested itself time and again in class discussions speculating about new problems and possible discoveries that might follow an exemplar's work. Putting people back into the material, the science became personally compelling.

In resolving certain contradictions between classroom practice and real-world learning and creating, we inadvertently stumble upon yet another: Knowledge can and may be purveyed efficiently, just as data may be streamed ever more quickly and in greater quantities through ever-more accessible means. Understanding, in contrast, can never be purveyed efficiently because it requires re-enactment. It requires that we take the time for our students to feel in and through the body what they know in concept. It requires that we, as educators, take time to practice best methods in learning and creating, such as emulating and copying, or problem posing and challenge identification, or questioning for clarification, exploration, hidden ignorance and hidden knowledge, or stimulating curiosity for what may be as yet unknown and undone. When it comes to learning for understanding, the classroom is not a factory, but a laboratory, an archive, an atelier.

That said, in the quest to educate for life-long learning and creativity, the re-creative model explored here is one among several possible pedagogical models, but a strong one. Emulating creative exemplars, whether people, products, problems, or processes draws students directly into the authentic experiences of constructive practice. If we want our students to understand well enough to create and invent, then we must provide them with an education that permits them to explore the entire range of copying strategies, for the more methods students emulate, the greater their probability of making the leap from re-creating to creating. We must allow them to choose their own personal network of mentors, alive and dead. We must encourage them to find their own problems and challenges through effective questioning. Finally, we must focus their education on principles, methods, and skills that will serve them in learning and creating across many disciplines, multiple careers, and succeeding life stages. This means they need to learn about the passions people bring to finding problems and meeting challenges, to making, inventing and creating. If students are to meet the future with confidence, they need to model best practice in the classroom and in their own lives.

This is not some utopian dream: master creators across the arts and sciences have always learned this way. Why not make the people-passions-problems approach a part of everyone's schooling?

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Chapter 10
Where Learning Meets Creativity: The Promise of Guided Play

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Abstract As the United States and other countries consider "educational reform," the discussion appears to be primarily about fostering basic skills and content knowledge. Our contention is that this approach is not sufficient. Instead, we argue that for twenty-first century success, we must also foster creativity to prepare today's children to excel and solve tomorrow's problems. In this chapter, we offer a thought experiment on how our educational system could achieve these dual goals. We propose that the answer might come from a clearer definition of what creativity actually is and from our attempts to infuse creativity into our classrooms through a pedagogical approach that we call "guided play."

10.1 Introduction

Forty students – ages 6–15 – form a circle on the wooden plank floor of the Brightworks School in San Francisco. This morning was like every other – the teacher stood up in front of the community holding an object in his right hand. He placed a wok in the center of the circle and proclaimed, "This is NOT a wok." Members of the community then volunteered their alternative possibilities: "a hat," one young boy announced as he placed the wok on his head. "Or maybe a sled," another added as she postured her body in the center of the wok holding tightly onto the sides of the pan.

Brightworks contrasts sharply with our image of traditional schools that dot the American landscape. Traditional schools are generally in weathered 1950s buildings with rectangular classrooms that perfectly house the desks lined up in rows,

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commanded by the large "teacher's" space in front of the blackboard (that has sometimes turned digital white). The agenda written out on the board at the front of the class dictates how the children will spend their day – 8–9 for reading; 9–9:45 for math; etc. Often missing are recess, art, social studies and even science. Teachers are poised to deliver content; students, like empty vessels, are intended to fill their heads and learn.

Herein lies the creative contradiction in modern education. Education is supposed to prepare students as thinkers and citizens who succeed in the world of tomorrow. Leaders in the workplace tell us that the global marketplace, in which today's students will operate, requires creative thinking rather than simple regurgitation of factoids that can easily be looked up on a hand-held device. The *Wall Street Journal* (Mantell, 2012), for example, cites flexibility as a must-have job skill. Flexible thinkers are creative innovators who put information together in new ways and transform that disparate knowledge into new, never-dreamed-of-before solutions. The *Harvard Business Review* (Groysberg, 2014) suggests that some of the skills top executives need are "team- and relationship-building" as well as "communication and presentation;" both require creativity in messaging and delivery. Accordingly, in a new book on research-based principles for raising successful children, Golinkoff and Hirsh-Pasek (2016) offer creativity as one of the "6 Cs," or core competencies, that children will need to succeed in the twenty-first century.

Brian Eno (2015), who believes that we are all creative artists in the way that we transform and ritualize "simple" activities such as eating and dressing, has noted how creativity is increasingly critical for us to adapt to the changes we now face:

> We're going to be in a world of ultrafast change. It's really accelerating at the moment and will continue to. … I think we're going to be even more full-time artists than we are now. And I don't just mean the professionals like me, I mean everybody, is going to have to be constantly involved in this activity … of being able to resynchronise with each other, to connect things together, to be able to make adventurous mind games about different futures, to be able to understand things (BBC Music John Peel Lecture).

Robert Sternberg (2009), Professor of Human Development at Cornell University, past President of the American Psychological Association, and an expert on intelligence and creativity puts it succinctly, "… citizens of the world need creativity to form a vision of where they want to go and to cope with change in the environment…" (p. 10). And Sternberg believes that creativity can be fostered. In their book, *How to Develop Student Creativity*, Sternberg and Williams (1996), posit 25 ways to develop creative thinking, many of which are embedded in the fabric of progressive schools like Brightworks.

Traditional schools do *anything but* inspire flexible thinking. Indeed, recent evidence suggests that the laser focus on academic skills like reading and math has left creativity and flexible thinking out of daily lesson plans. And children are feeling the consequences. A headline story of a 2010 edition of *Newsweek* suggests that we are suffering from a "Creativity Crisis" (Bronson & Merryman, 2010). The authors highlight findings from Kim (2011), who examined longitudinal data including 300,000 scores on the classic Torrance Test of Creative Thinking and found that children's scores have been steadily decreasing over the last two decades. Using the "gold standard" of creativity testing, today's children are simply less creative than they were in 1980! That is, the average child today would do not do well in the Brightworks morning activity of finding alternative uses for a wok, because their education is largely about filling in a blank on a test.

The challenge plaguing educators is to preserve a strong education that offers children content in many areas, but that is also responsive to the demands of a twenty-first century economy. As Sir Ken Robinson (2006) broadcast in his popular TED talk, "Do Schools Kill Creativity?":

> My contention is that creativity now is as important in education as literacy, and we should treat it with the same status…. Our education system is predicated on the idea of academic ability. … which has really come to dominate our view of intelligence….And the consequence is that many highly-talented, brilliant, creative people think they're not, because the thing they were good at at school wasn't valued, or was actually stigmatized. And I think we can't afford to go on that way. (approximately 2:20 into video file)

Reconciling this apparent contradiction between school practices and the needs of the twenty-first century global workforce is one of the greatest challenges in education. However, many who are proposing "educational reform" are not talking about promoting creativity but about fostering basic skills. Our contention is that this approach is not sufficient. We are motivated to consider how to foster creativity in students of this next generation. In this chapter, we offer a thought experiment to address this question. We propose that the answer might come from a clearer definition of what creativity actually is and from our attempts to infuse creativity into our classrooms through a pedagogical approach that we call "guided play" – an approach that is at least partially endorsed in progressive schools like Brightworks.

10.2 Creativity Is…

Education is like a large cargo ship that moves slowly even when amidst winds of change. Adding creative innovation and flexible thinking is important in educating our children. Yet, even the widely used preschool curricula called *The Creative Curriculum* offers only a few call-outs to creativity as an outcome – nested within the "Cognitive" objectives for development and learning (Teaching Strategies, 2013). Part of the problem stems from the academic community itself that has been slow to offer a clear and coherent definition of creativity. And without a clear definition, it is difficult to offer psychometrically strong measures to chart progress in the creative domain. In other words, in these days of accountability, if something cannot be measured, it is often considered unimportant. A recent piece published by the National Endowment for the Arts (2015) reviewed findings from the Santa Fe Conference entitled *How Creativity Works in the Brain*. It offers this statement in its executive summary:

> … cognitive psychologist Mark Runko, of the University of Georgia, summarized 30-year trends in the field of psychology-based creativity research. It rapidly became clear to working group members that no single generalizable theory of creativity has yet emerged (p. 10).

Creativity is a complex and multifaceted construct that does not lend itself to easy translation in a classroom. If scientists themselves are unsure of what creativity is and have no way to gauge progress in this area, many worry that it will be difficult to design curricula with creativity as a stated outcome.

Most of the studies that do exist – at least with respect to children – define creativity as a synonym for *divergent thinking* – our ability to produce a variety of answers to open-ended questions (Dietrich & Kanso, 2010 for a review; Guilford, 1950, 1967; Jung, Mead, Carrasco, & Flores, 2013). The focus on divergent thinking as the bedrock of creativity came from early and outstanding work by psychometrician J.P. Guilford (1967) who described divergent thinking (and hence creativity) as, "[the] generation of information from given information, where emphasis is upon variety and quantity of output from the same source, likely to involve transfer." (p. 213). This focus on quantity became the oft-cited reliance on *fluency* as a measure of creative expression. The descriptor *variety* is meant to refer to diversity or divergence from a single source, often measured as *originality* of responses. Thus, the quintessential *unusual uses* task[1] (Wilson, Guilford, & Christensen, 1953) became the pillar upon which modern creativity research was born. In that task, participants state as many different uses as they can for a common object like a brick. A creative person is defined as one who can generate many responses (i.e., be "fluent"), many of which are unusual or clever (i.e., "original").

Today, the two most common verbal divergent thinking tests used with children are the verbal Torrance Test (Torrance, 1966) and the Wallach and Kogan (1965) test. Both stem from, but extend beyond, the unusual uses task. The Torrance Test (see Kim, 2006 for a review) is a battery of tasks that asks children to create unusual uses for objects, to name ways a toy can be improved, and that prompts children to ask, and answer, questions about a picture that serves only as a support. The Wallach and Kogan task similarly requires children to name as many instances in response to a prompt as they can (e.g., things that are round) along with an unusual uses task, and a similarities task in which children identify the similarities between two items. Of the available tests, Plucker (1999) argues that the Torrance Test, "appear to be the best cognitive predictor of creative achievement over which we can have an appreciable educational impact (p. 111)." One could argue that the opening exercise at the Brightworks school offered a textbook case of divergent thinking and was, in many ways, a scaled-up version of the Torrance Test.

In their book, *Becoming brilliant: What science tells us about raising successful children*, Golinkoff and Hirsh-Pasek (2016) agree with Sternberg and Williams (1996) and suggest that children can be taught to be more creative. They begin by outlining, in broad strokes, a scientific consensus view of the development of creativity through 4-levels. The first step for children (or adults) is to engage in *experimentation*. This experimentation and exploration is not in the service of a goal or to solve a problem. It is simply exploration of the space – be it the tools used in building or the paints used to splash color on a canvas. What can paints do? How can they be used? In this fundamental step of creativity, we experiment to see what hap-

[1] Also known as the alternative uses task, or simply the uses task.

pens. Novice creators are not constrained with preconceived notions of how things work. Children are free to pretend that the yogurt lid really is a stethoscope – or a cookie cutter – or a wheel.

In the second level, children transition to *means-end creativity*. This is not creativity merely for exploration's sake. Rather, this kind of creativity results from our attempts to solve a problem. Much like infants who creatively figure out a way to escape from the crib, children flex their creative muscles with the hope that they can solve the problem in front of them. At first, they constrain their responses to a range of possible solutions they have witnessed before – as when an infant is lifted over the sides of the crib. But by Level 2, children are intentionally engaging in creative production for extended periods of time, directing it toward a goal they can identify – even if onlookers cannot. We can think of Level 2 as using the same means (materials) to create diverse ends and also as using different means (blocks, paint, clay) in new ways. When infants attempt to squeeze through the crib bars – even if they are unsuccessful – they are exploring new means to achieve their ends.

At the next level, children develop their own *voice* and add their own personal expression to their creative accomplishments. Here, they use tools more purposely to express an outcome. From a child creating a round house out of a square building set or a poet creating a new genre of sonnets, a key step on the trajectory of creativity is achieved when children begin to blend what they know to fit the problem space. At the second level, children writing a book report merely recount what they read in the book. Here, at level three, they begin to develop a thesis that blends what they read with what they know to give their own view and interpretation to the report. Crucially, children (or adults) must have existing conceptual knowledge to arrive at this level. Someone without basic understanding of physics cannot create a new equation nor can a child without knowledge of the topic in the book write a new ending.

In the last level, *vision*, we see that children and adults build upon their existing knowledge and solve a problem in a brand new way. Revolutionary thinkers do not merely write a paper within a standard book report format. They develop the new and improved format that allows them to more fully express the thematic content of the book as they see it. Notably, a major requirement of this step is that thinkers not just create something new, but that they envision an entirely new solution. They do not merely complete the puzzle from old parts, but literally create new pieces. It is not so much about a slight improvement on an existing product or idea, but the generation of a brand new product or idea. And this final step in the trajectory is not limited to adults. Artist and educator Beau Lotto asked 8–10-year olds to come up with a question of their choosing and they creatively asked whether bumblebees could think like humans. These students (along with Lotto and their head teacher) developed an empirical question (can bees use colors and patterns to recognize whether a flower will be nourishing or not?) and a method to test this question (complete with a color-coded puzzle beehive). Their results were published in the journal *Biology Letters* (Blackawton et al., 2011). Indeed, today's children can reach this visionary level.

A glance at the range of behavior that sits under the umbrella of creativity allows us to quickly see that limiting the definition of creativity to divergent thinking will ultimately constrain our efforts to nurture creativity as an outcome in our schools. To be fair, a number of recent works examine the construct with respect to the way people provide solutions to ill-defined problems – problems that do not have prespecified solutions; for example how might we design a new coffee cup (Chrysikou & Weisberg, 2005) or a new sport (Ward, 2008). At Brightworks, the opening exercise permitted the children to look at the world in an original way. But in their smaller "working groups", students in the program were also busy creating new conceptions of fashion and designing new types of planters that could be made in their fully equipped shop.

Progressive schools ask how creativity can be infused throughout the school day. And even if they focus more squarely on divergent thinking, this would surely be an advance over the white-walled, lecture-based environments that often inspire little or no creative thinking. Lest the pendulum swing too far, though, the challenge is really to honor creativity while offering a rich curricular approach to learning content and learning-to-learn skills such as maintaining focus and attention.

Yet the drive for teaching for creativity and content is not just found in the United States. A great irony is that China wants to encourage creativity just as the United States has returned to nineteenth century educational methods and encouraged memorization for high stakes tests. In fact, Betty Preus (2007), a professor of education at The College of Saint Scholastica in Minnesota, quotes a visiting professor from China as saying, "It is interesting that something we learn from you is just what you want to change." China wants to de-emphasize rote learning because they recognize they are creating passive, unmotivated students who are interested only in passing tests. They now want to emphasize creativity (Zhao, 2009).

Next, we discuss the type of pedagogy that encourages the deep learning of content and possibly encourages creative thinking as well. For young children, we refer to this pedagogical technique as "playful learning" but it is really a metaphor for engaged learning in which children actively participate (Fisher, Hirsh-Pasek, Golinkoff, Singer, & Berk, 2010; Hirsh-Pasek, Golinkoff, Berk, & Singer, 2009; Weisberg, Hirsh-Pasek, & Golinkoff, 2013). Others too have made similar suggestions, specifically with respect to the cultivation of creativity.

10.3 A Promising Approach: Playful Learning as a Blend of Creativity and Content Learning

Russ and Wallace (2013) suggest that one way to bundle creativity and core content is through playful learning. They first ask us to consider how play might foster creativity:

> Both pretend play and creativity are multidimensional, and there are many similarities between the processes that occur in both of them (Russ, 1993, 2004, 2014). Creativity

> researchers, beginning with Guilford in 1950, have identified cognitive abilities as especially important for creativity, and many of these also characterize pretend play – divergent thinking, broad associative skill, insight, cognitive flexibility, and perspective taking. (p. 137).

There is scattered research to suggest that play is indeed related to increases in creativity, though the research is admittedly thin. Howard-Jones, Taylor, and Sutton (2002) presented 6–7-year-old children with either a 'free play' task in which they played with salt dough for 25 min or a task in which they were directly instructed to copy text from the board. Then, children were tasked with creating a collage of a creature using tissue paper. Those children who were given the opportunity to engage in free play created more imaginative creatures (as judged by an expert independent panel) and used more colors than those in the direct-instruction context. Whether the direct instruction decreased creativity or the free play increased creativity is an open question and one ripe for investigation. However, a possible clue comes from a recent study with college students. Moreau and Engeset (2016) found that students given a LEGO kit with a well-defined goal later performed worse on items from the Torrance Test of Creativity compared to those given LEGOS with no defined goal (e.g., free form play with LEGOS) and a control group that was not exposed to the LEGOS. Stressing that there is a 'right' answer seems to prevent students from thinking flexibly and creatively – even on a subsequent unrelated task.

Given the state of the art, it is no wonder that Russ and Wallace (2013), despite their enthusiasm for a strong bond between creativity and play, caution, "A real dilemma is exactly what to recommend to teachers and child-care workers about facilitating play and creativity in the classroom. We do not have a well-validated protocol to facilitate play in the classroom that also increases creative thinking" (p. 146). Clearly more high quality data is needed to secure this link.

But perhaps we should take a step back to ask what we mean by play and why we might expect a link to creativity. In alignment with the literature, Weisberg, Zosh, Hirsh-Pasek, and Golinkoff (2013) outline three main characteristics of play that separate it from other activities:

> First, play has no specific purpose, and it is not linked to survival. Second, playful activities are often exaggerated—a pretend action often takes longer or involves a wider range of motion than a similar real action. Finally, play is joyful and voluntary (p. 41).

Using play invites children to think, to consider, and to make decisions for themselves within a joyful, voluntary context. Creativity is more likely to be nurtured during play than when children are told what to do. During play, children think for themselves, create new worlds, and experiment with how things might be. Hirsh-Pasek et al. (2009) provide a further refinement of the term "play." They discuss the merits of playful learning – a whole-child approach that stimulates children's academic, socio-emotional, and cognitive development (Fisher et al., 2010; Hirsh-Pasek & Golinkoff, 2011; Resnick, 2003; Weisberg et al., 2013; Weisberg, Kittredge, Hirsh-Pasek, Golinkoff, & Klahr, 2015). However, they propose that playful learning is an umbrella term that encompasses two separate types of play: *free play* and *guided play. Free play* is inherently voluntary, non-goal directed, controlled by the child, and often contains an element of make-believe. Some theorists argue that free play is sufficient for furthering a child's education (Gray, 2013). *Guided play*, on the other hand, is led by the child and is designed to be fun and flexible, but has the ultimate goal of building a child's skillset or knowledge. Weisberg and colleagues (2013) define guided play as an activity that:

> …incorporates adult-scaffolded learning objectives but remains child-directed. In guided play, adults initiate the learning process, constrain the learning goals, and are responsible for maintaining focus on these goals even as the child guides his or her own discovery. This latter point is critical. While adults might initiate the play sequence, children direct their own learning within the play context. Thus, guided play is *child-directed* and can take a number of paths within a play setting (p. 105).

Thus, guided play is likely to have two effects. First, it is likely to facilitate learning as children become agents, playing a role in directing their own learning experience. Second, once children are encouraged to take an active role in their own learning, guided play is expected to foster innovative thinking and creativity. We next evaluate whether these two hypotheses appear to be true. There is more evidence for the value of guided play for children's learning than there is for whether guided play spurs creativity. Yet we argue that guided play is likely to be a springboard for creativity and a better bet for a classroom pedagogy if both content and creativity are the end goal.

10.4 The Value of Guided Play for Children's Learning

In their meta-analysis of 164 studies, Alfieri, Brooks, Aldrich, and Tenenbaum (2011) examined a range of pedagogies with respect to their potency for child learning. They found that when one compared direct instruction to free play, direct instruction was a more effective pedagogical method. However, when compared to guided play, direct instruction was not optimal. Guided play, or what Alfieri and colleagues (2011) called 'assisted discovery,' trumped other pedagogical approaches for content and social learning. This finding has emerged in a number of reviews and studies (Fisher, Hirsh-Pasek, Newcombe & Golinkoff, 2013; Hirsh-Pasek et al., 2009; Zosh, Hirsh-Pasek, & Golinkoff, 2015). As described below, guided play has been found to support learning across diverse domains, such as mathematics, spatial learning, language and literacy, and emotion regulation.

Take, for example, a now-classic guided play study in mathematics. Ramani and Siegler (2008) asked whether using playful learning techniques in an intervention with preschool children could help them to develop a linear representation of number along a mental number line. They developed a game for children to play using numbers as the places on the game board. With as little as an hour's worth of game play, low-income children showed improvement in five different areas of mathematical thinking. This effect held even 9 weeks later. Crucially, the effect in mathematical thinking did not come merely because a game was played. When the numbers were replaced with colors on the game board, no mathematical benefit accrued. Thus, this study showed that children can learn new skills in a guided play situation in which the adult has clear learning goals in mind (see Hirsh-Pasek, Zosh et al., 2015 for a similar argument with educational apps).

Guided play has also proven effective in learning geometric concepts. Fisher and colleagues (2013) compared children's learning about geometric shapes in three conditions: In guided play, an adult helped children "figure out the secrets of the shapes," that is, what makes a triangle a triangle. The adult helped the child to count the sides of the shapes, for example, after the child noticed that this might be a key feature. In didactic instruction, an adult showed the child the shapes' secrets while the child watched and listened. Finally, in free play, children were allowed to play with the shapes however they wished. The children in the free play condition, who were unconstrained in their task, did well below chance in identifying which shapes were "real." Children who learned via guided play were not only 20 % better than children in the didactic instruction condition, but were over 35 % better at identifying *non-typical* shapes they had not previously been shown. For example, children agreed that a lopsided triangle was a "real" triangle even if the point was not on the top. This latter finding suggests that guided play encouraged children to truly incorporate what the "secrets" of the shapes were. Their active role in discovering these secrets may have been the key in their better performance. Impressively, those who learned in guided play also showed increased retention of geometric concepts a week later.

The development of language and literacy offers a third area in which guided play has been put to the test (Weisberg et al., 2013; Zosh, Reed, Golinkoff, & Hirsh-Pasek, 2014 for a review). At-risk children who received direct vocabulary instruction coupled with guided play showed more vocabulary growth than children who received only direct instruction for the same amount of time (Han, Moore, Vukelich, & Buell, 2010). Guided play also outperformed free play in a large-scale intervention-based study: Preschoolers in Head Start who heard vocabulary in a book and then engaged in guided play learned more words than children who engaged in free play after book-reading (Dickinson, Hirsh-Pasek, Golinkoff, Nicolopoulou, & Collins, 2013).

Finally, research into intervention to foster social regulation or executive function also supports a playful learning approach. In their now-classic Tools of the Mind program, Bodrova and Leong (2001) suggest that when children play particular games throughout the school day, they develop the kind of regulation and impulse control behaviors that predict school outcomes in language, literacy, and mathematics (Diamond, Barnett, Thomas & Munro, 2007; Blair & Raver, 2014). In pretend play for example, children tell their teacher what their theme will be and who will play what part. Thus, the value of playful learning and in particular, guided play, is not restricted to academic outcomes, but also to social growth and to learning to learn behaviors that correlate with other markers of child success.

It is important to note that our endorsement of guided play does not come at the expense of direct instruction. Quite the contrary. There are domains and contexts in which direct instruction is as good as or sometimes even better in achieving outcomes than is guided play. In the language and literacy studies reported above, for example, vocabulary was learned equally well in "play" where the teacher played director, and in guided play where children led. Both types of play trumped vocabulary learning in free play. When the adult has a learning goal in mind – here vocabulary learning – it is imperative to narrow the child's search space for possible meanings of a word. Both guided and directed play achieve that end. Klahr and Nigam (2004) also champion the idea that direct instruction might be the only way to convey information in some domains, like some aspects of scientific learning. Though they embrace many traits of guided play, this research finds that third and fourth graders learn how to narrow down a hypothesis better when they are directed towards the critical experiment than when they are lost at sea with a more discovery-based pedagogy.

Bonawitz and colleagues (2011) suggest, however, that even in these cases, direct instruction can be a 'double-edged sword': While it can give the learner information in an immediate context, it actually serves to decrease the learner's drive for exploration and further discovery. Their studies presented children with a novel toy that had a number of functions. When the experimenters instructed the children about one of those four functions, the child indeed learned that function, providing evidence that direction instruction or modeling can work. However, children who were instructed about that function were also less likely to discover the other non-demonstrated functions. In stark contrast, children who simply got the exact same object to explore on their own engaged in active exploration and uncovered significantly more of these hidden functions (Bonawitz et al., 2011).

In sum, direct instruction – the currency of today's educational landscape – has proven somewhat effective in transmitting information from teacher to student. But research suggests that guided play offers an equally and possibly more effective pedagogy. It invites children to master material in an atmosphere that inspires a more positive approach to learning. If guided play holds the promise of sparking creative thinking and provides a pedagogical solution to content learning, then it might take us a long way towards reaching the twin goals of fostering creativity while also supporting content learning.

10.5 Why Might Guided Play Promote Creativity?

Although both types of playful learning are valuable, the research we have reviewed suggests that when an adult has a curricular goal in mind, guided play is more effective for learning than free play. We further contend that guided play has an additional advantage: Although the research needs to be done, guided play may open children to more creative possibilities than free play. A recent paper by Weisberg and colleagues (Weisberg, Hirsh-Pasek, Golinkoff, & McCandliss, 2014) asks why guided play could harbor such a promising approach for education. They suggest that guided play helps children set a *mise en place*, or a prepared mindset, for learning and possibly for nurturing creativity. In other words, during guided play, children actively explore and discover new conceptual understanding with the help of adults who scaffold and support but do not lead the experience. It stokes what Galinsky (2010) called the “fire in the child’s eyes.” In so doing, it offers children stewardship of their own learning with adults playing the supporting role of scaffolding their exploration.

Just as a chef who is given a bountiful pantry with high-quality ingredients can create a wonderful meal, guided play happens when adults provide a high quality experience while giving children opportunities to create their own understanding. Adults still play an essential role. In guided play, adults narrow the list of “ingredients” to make high quality learning possible. Adults support learning by constraining the possibilities so that children can discover what is important. A child in free play is like a novice chef who is overwhelmed or ill-equipped to make the correct choices when confronted by so many supermarket aisles and cuts of meat. Adults not only prepare the choice of potential ingredients, but also stand by to gently support the young chef as she explores how the ingredients work together – constantly observing and expanding her purview. In this way the child grows from novice explorer towards seasoned expert.

Guided play – or engaged learning in which the child has a strong role – might foster that seasoned expert for a number of reasons, allowing for the learning of content and the nurturance of creativity. One reason is that as the *mise en place*, or prepared mindset, is established, children are given the opportunity to participate and think in new ways. Their task is not to collect the ingredients but to create something new with what is in front of them. Another potential advantage is that guided play seems to lead to greater understanding of the newly learned content. If children form a deeper representation of the content, such as a better understanding of the properties of geometric forms (Fisher et al., 2013), they are then in a position to manipulate it and use it for new ends. Knowing, for example, that squares and rectangles can be divided into triangles may lead children to create more imaginative geometric puzzles.

One example of how guided play may promote creativity comes from a yearlong study of a play-based intervention designed to increase creativity in 10–11-year-olds (Garaigordobil, 2006). In the intervention, teachers led students through several different games and activities that incorporated fiction and creation as well as cooperation and communication among students. For example, in one activity students worked in small groups to plan and act out an advertisement for a real or invented product or service. Although the intervention was not designed from a guided play perspective, the activities had many features that align with principles of guided play. First, each play session was led by a teacher – children were not simply given free reign in a classroom. Second, the activities for each play session were structured and guided by the researcher with clear goals in mind, including increasing creativity but also promoting socioemotional development. Finally, once the context was set by the teacher, the children were given the ability to participate in the activity – they were not just told exactly what to do. Garaigordobil (2006) found that children in the intervention showed increased creativity on a subset of Torrance’s Test of Creative Thinking tasks (increased originality, as expressed though verbal creativity and greater graphic–figural creativity) from pre-test at the beginning of the school year to post-test at the end of the school year, relative to a control group of children who did not participate in the intervention. A similar play-based intervention program sharing characteristics with guided play has also shown to be effective with even younger children aged 5–6 years (Garaigordobil & Berrueco, 2011).

Children's activity during guided play clearly encourages children to think. This is not to say that direct instruction or free play does not involve thinking. They do. But because in guided play children are not just receiving information but helping to generate it, children's thinking may be nuanced and deeper. The suggestion that children who learn with a guided play pedagogy are better at transfer, or taking their learning to new places, is important to build on. Encouraging children to think and not just memorize may serve to stoke children's creativity.

10.6 Where Do We Go from Here?

In 2006, a *Time Magazine* article quipped that if Rip van Winkle woke up today only one institution would be familiar – the schools (Wallis & Steptoe, 2006). Everything else in our modern society would be totally novel to him: Business has entered the twenty-first century global economy at warp speed, geographic boundaries are more porous, and many have found their voice in a free market of ideas that travel the world in seconds through blogs, texts and social media posts. Rip never heard of these rapid-fire communication techniques and would likely be overwhelmed. The photographer who is locked into metal case film cartridges is doomed, as is the journalist who pecks out a local story on his Smith Corona. We all needed to adapt to the fast pace of change that demands leadership, creativity and the ability to solve ill-defined problems. The schools – designed for the agrarian society with lined desks in square rooms – are simply not equipping our children for the society of the present, let alone the future. Rip might find solace in the familiar surroundings. For our children these characteristics portend disaster.

Research in the science of learning (e.g., Sawyer, 2014) offers us a glimpse of what is required for developing strong curricula that foster creativity but we are less sure how to get there. There are many reasons why global education seems to be sinking in hundred-year-old quicksand. One is that we often treat educational change by patching what we have done in the past. Putting a bigger set of wheels or a better steering mechanism on a horse and buggy, however, still leaves one with a horse and buggy. The school in its current form is outdated and is not preparing children for their future. Perhaps we need a "green field" experiment that asks – if we were to build a school around the skills children need for the mid-twenty-first century, what would it look like? Golinkoff and Hirsh-Pasek (2016) entertain that very idea in their book. They offer an evidence-grounded way to think about a new model for education.

We simply do not know enough about how to think about creativity and how to nurture it to ensure that the curriculum we build will be evidence-based. In this paper, we offer a thought experiment and invite researchers and educators to think about guided play as a promising avenue towards understanding creativity and how it can be nurtured and measured as an outcome in our schools. The data suggest, but do not secure, that guided play should, theoretically, promote creativity. The current research relies heavily on correlational and observational data, but the weight of the evidence is in favor of this relationship. The data more clearly suggest that children can master content and social regulation in a playful learning environment. Given that children need both content and creative thinking, we suggest that playful learning shines a light on a new area for serious research. It might just be a good bet for resolving the creative contradiction that exists in our schools. Final answer – more research is needed.

Yet, as we ponder the creative contradiction, we close with yet another thought experiment. If you knew that you had a drug that was not well tested, but that looked promising, would you give it to a dying patient? The science suggests that the drug surely will not hurt the patient – there are in fact a number of potential upsides. The patient: our educational system. The drug: playful learning.

If the answer to this question is YES, then we suggest that we put a stake in the ground and define creativity for the moment as divergent thinking and that we find ways to encourage and support divergent thinking in the classroom. We start our days like they do at Brightworks and we study whether such interventions have any short- and long-term effects. We also ask how we might inspire more of a Maker-Mentality (Honey & Kanter, 2013; Maker Faire n.d.) in the schools where class time is actually spent on Rube Goldberg questions like how you build a better mousetrap. Once we establish how to promote divergent thinking, we will then have a foundation upon which we can build to support other types of creativity.

At the same time, our well-thought-out curriculum will not simply be focused on content like reading and writing, reading and writing, and reading and writing, but also on what Golinkoff and Hirsh-Pasek (2016) called the 6 Cs of successful children: collaboration, communication, content, critical thinking, creative innovation and confidence. These skills are based in the science of learning, are malleable, and, crucially, are the skills necessary for twenty-first century success. Our ideal school will guide learners through the development of each of these skills from the basic to the transformative by leveraging the principles of guided play to prepare tomorrow's leaders.

We would start our visionary school at the preschool level and add a grade each year until all children could benefit from an engaging school climate that was creative and content rich. The science to date suggests that this is possible. It will, however, not be done by patching the horse and buggy or by making Rip van Winkle more comfortable. It will be done by bold educational entrepreneurs who invent schools like Brightworks, building on what we know from the science of learning to uncover novel ways to promote creativity as part of a cohesive curriculum.

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Chapter 11
Contradictory Concepts of Creativity in Mathematics Teacher Education

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Abstract The focus of this chapter is a study of teacher educators' conceptions of the relationship between mathematics and creativity. A particular focus was on the apparent contradictions between the conceptions of mathematics and creativity found in schools, as opposed to conceptions found within the society of professional mathematicians. We interviewed a focus group of teacher educators. A set of questions on mathematics and creativity was prepared, and the interviews consisted of an open discussion among the focus group around these questions. We carried out a thematic analysis of the interviews. This kind of exploratory study of teacher educators' conceptions of mathematics and creativity in Norway is new and shows that the teacher educators in the focus group have similar concepts of mathematics and creativity to those which we find in much of the current research on mathematics and creativity.

11.1 Introduction

Why do learners in school often experience mathematics as an exercise in rote learning, yet mathematicians describe their field as highly creative? Mathematical creativity ensures the growth of the field (Sriraman, 2009) and solving problems is at the heart of mathematics (Halmos, 1980). Work in advanced mathematics is full of uncertainty but curricular and pedagogical approaches rarely offer students this open-ended view of mathematics (Sriraman, 2005). In this exploratory study, we investigate this contradiction between school mathematics and advanced mathematics by focusing on teacher educators. Teacher educators are often mathematicians themselves, who teach pre-service teachers, who eventually end up as teachers in school. We therefore decided to focus on teacher educators, because they work as a link between advanced mathematics and school mathematics.

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Research into teacher educators in Norway (and in general into mathematical creativity) is sparse. The research question of the study is therefore: What are teacher educators' concepts of mathematical creativity?" We will have a particular focus on creativity as the difference between school mathematics and advanced mathematics.

In Thompson's (1992) review of the literature on teachers' *beliefs* and *conceptions*, she noted the importance of studying teachers' beliefs and conceptions, because these perspectives influence their actions and teaching. However, as Philipp (2007) asserts, the term 'conception' is not uniformly used in the literature. Many researchers write about conceptions, without ever defining it: researchers have often assumed, implicitly, that readers know what conceptions are. As a result, in this study, we have chosen to define conceptions broadly, in a way that can capture the full range of the teacher educators' statements: "conception is a general notion or mental structure encompassing beliefs, meanings, concepts, propositions, rules, mental images, and preferences" (Philipp, 2007). This is similar to Thompson's description of conceptions, in which they are seen as a construct that integrates both knowledge and beliefs, in which beliefs "are psychologically held understandings, premises or propositions about the world that are thought to be true." (Philipp, 2007).

11.2 Literature Review

In this study, we ask why learners of mathematics experience mathematics as a rote learning experience while mathematicians say that mathematics is a creative endeavour. This question indicates a contradiction between school mathematics and the professional business of mathematics so we will now look at what the literature can tell us.

Lithner's (2000) study concerns the solving strategies of undergraduate mathematics students. The participating students were finishing their first semester of their university studies in mathematics. The results indicate that focusing on what is familiar and remembered at a superficial level dominates reasoning based on the mathematical properties of the components involved. Lithner makes the distinction between plausible reasoning, which is an extended version of proof reasoning, and reasoning based on established experience from the learning environment, which might be superficial.

Polya (1954, pp. v–vi) makes the point that there are two kinds of reasoning in mathematics. There is demonstrative reasoning and there is plausible reasoning. Demonstrative reasoning has rigid standards based on formal logic. It is the kind of reasoning that appears in mathematical proofs. Plausible reasoning is less secure and more provisional than demonstrative reasoning. According to Polya (1954, pp. vi), "the result of the mathematician's creative work is demonstrative reasoning, a proof; but the proof is discovered by plausible reasoning, by guessing." Polya makes the point that plausible reasoning and demonstrative reasoning do not contradict each other. On the contrary, they complete each other.

Lithner (2000) defines plausible reasoning as mathematical reasoning founded on the mathematical properties of the components involved in the reasoning. Reasoning based on established experience is reasoning founded on the notions and procedures of the individual's previous learning experiences. An example of this kind of reasoning would be as follows. Suppose the task is to find the critical points of a given function f. If a student tries to solve this task by solving the equation $f'(x)=0$ simply because this has always worked before, then this student would be doing reasoning based on established experience. This might be superficial reasoning. Thus, according to Lithner, plausible reasoning and reasoning based on established experience do contradict each other.

Bergqvist (2007) classified over 200 tasks from 16 introductory calculus course exams. The data are from all introductory calculus courses offered at four different Swedish universities during the academic year 2003/2004. The purpose was to examine the reasoning that Swedish university mathematics students perform in order to solve exam tasks and pass the exams. The results showed that almost all exams were possible to pass using reasoning based on rote learning. Bergqvist identifies different kinds of mathematical reasoning based on rote learning, such as memorised reasoning and algorithmic reasoning. A typical task solvable by memorised reasoning would be asking for facts, such as definitions, e.g., "What does it mean for a function f to be differentiable at the point x_0?" A typical characteristic of algorithmic reasoning is that it is founded on remembering a set of rules that can be performed and which will give a correct answer if executed correctly, e.g., "Differentiate $f(x)=(x^2+x)/(x^2-1)$". Some students probably do this without an understanding of the intrinsic mathematical properties of the components involved in the reasoning.

In order to study how mathematics is created, Sriraman (2009) investigated the work of five research mathematicians. By interviewing and analysing the interview transcripts, he found that, in general, the creative process of the mathematicians followed the four stage Gestalt model of preparation-incubation-illumination-verification of Wallas (1926). In his essay, Hadamard (1954) discusses his own, as well as others', research in the mathematical field, also using the Gestalt model. Sriraman discusses the problem of defining creativity, and he concludes that it is sufficient to define creativity as the ability to produce novel or original work. Sriraman asks the following questions:

- Is the Gestalt model of mathematical creativity still applicable today?
- What are the characteristics of the creative process in mathematics?
- Does the study of mathematical creativity have any implications for the classroom?

The studies of Lithner (2000) and Bergqvist (2007) indicate that it might be interesting to rephrase these questions, not only asking if the Gestalt model of creativity is still applicable, but for whom is it applicable? If the mathematical tasks the students are given basically involve rote learning reasoning, as indicated by Lithner and Bergqvist, then perhaps creativity is not a part of the mathematical reasoning in the classroom. As indicated by Sriraman (2009), the Gestalt model is applicable to professional mathematicians. However, it is perhaps difficult to see how the Gestalt model applies to the classroom where the students can hardly have a period of incubation and sleep on it. Therefore, it would be natural to ask if the characteristics of the creative process are the same for different individuals. It might be different for, say, a professional mathematician than a student of mathematics.

Beghetto and Kaufman (2008) make the point that creativity is usually defined as the ability to produce work that is novel or original, as well as useful. The usefulness has a broader meaning, including meaningfulness and appropriateness as defined by the relevant gatekeepers. According to Beghetto and Kaufman, creativity scholars have traditionally made a distinction between eminent creativity and everyday creativity. The first category of creativity is labeled 'Big-C' and the second category is labeled 'little-c'. An example of Big-C creativity would be Mozart's compositions, and an example of little-c creativity would be the creative way someone arranges their plants and flowers in the garden.

The question is whether it makes sense to characterise a student's discovery of an already known result as creative. Beghetto and Kaufman (2008) suggests that aspects of creativity are involved in students' self-discoveries and externally recognised discoveries of professionals, because both involve new and meaningful insight even though self-discoveries might not be new to the professional community.

The Four-C Model of Creativity of Beghetto and Kaufman (2008) expands the Big-C/little-c dichotomy to include two additional categories: 'mini-c' and 'Pro-c' creativity. Mini-c creativity relates to the novel insights of self-discovery, even though the discoveries are not new to the professional community. Pro-c creativity refers to discoveries at the professional level even though they are not yet considered as eminent by the professional community.

Haylock (1987) reviewed some of the research and literature associated with creativity in school mathematics, mainly from English speaking countries. Two key aspects emerged, the ability to overcome *fixations* in mathematical problem-solving, and the ability for *divergent productions* within mathematical situations. Haylock (1987, pp. 64) makes the point that, "All mathematics educators will have had experience of children showing stubborn adherence to inappropriate methods or algorithms when tackling mathematical problems". According to Haylock, two key aspects emerge as having most relevance, *algorithmic fixation* and *content universe fixation*. A pupil who continues to use an initially successful algorithm even when this has become inappropriate or less than optimal is showing algorithmic fixation. The pupil who limits inappropriately or unnecessarily the range of elements that may be used to solve a mathematical problem is showing content universe fixation. *Flexibility*, on the other hand, is shown in overcoming fixations.

The common element in divergent production situations is that the subject is working on a problem with many solutions, as opposed to a mathematical problem with a single solution, which would require *convergent* thinking. The example given by Haylock is to give the subject a brick and ask for all possible uses of that brick.

Lithner (2008) introduced a research framework to analyse mathematical reasoning. The framework is based on empirical data and addresses the problem of rote learning. The basic idea is that rote learning is *imitative*, while the opposite reasoning is *creative*. Students who copy a line of reasoning given to them step by step would be doing imitative reasoning. Textbooks often give examples of how to solve tasks. If that is the case, all that is needed to solve such tasks would be imitative reasoning.

Lithner (2008) characterises *creative mathematically founded reasoning* as follows:

1. Novelty. A new (to the reasoner) reasoning sequence is created, or a forgotten one is recreated.
2. Plausibility. There are arguments supporting the strategy choice and/or strategy implementation motivating why the conclusions are true or plausible.
3. Mathematical foundation. The arguments are anchored in intrinsic mathematical properties of the components involved in the reasoning.

Birkeland (2015) investigated the mathematical reasoning of pre-service teachers by organising a class of students into small groups and giving them some tasks to work through. The students were preparing to teach grades five to 10. The tasks given to the students were on sequences: the students had to find the general expression for each term of a given sequence. That is, they were given a sequence (x_n) and had to find an expression for x_n. The analysis showed that some of the students' reasoning was imitative. However, some of the students' reasoning was not imitative. The students were given a hint to get started, but they were not given a complete solution: the students had to contribute their own reasoning. Even though the students' reasoning was not imitative, Birkeland did not categorise their reasoning as creative, either. The reason for this was that the students' reasoning probably had no novelty. However, the students' reasoning did have flexibility. Therefore, in this paper, a distinction between imitative and non-imitative reasoning replaces the distinction between imitative and creative reasoning.

11.3 Methods

To answer our main research question, we conducted a series of semi-structured focus group interviews with teacher educators. The main research question led us to focus our investigation to examining what goes on 'inside a person's head' through interviews, as Tuckman (1972) described it. Focus groups are a form of group interviews, in which data is gathered, analysed and interpreted, primarily on the basis of group interaction rather than interaction between the interviewer and the group. Thus, focus group interviews allows the researcher to investigate a collective view rather than an individual view (Morgan, 1988) as data emerge in the interaction of the group (Cohen, Manion, & Morrison, 2007). Semi-structured interviews in focus groups were also chosen due to the fact that they yield insights that might not otherwise have been available in a straightforward interview and they are economical in the sense that they produce a large amount of data in a short period of time. This was particularly useful, as the research on teacher educators' conceptions of mathematical creativity is sparse and the use of focus groups allowed us to efficiently develop themes and a hypothesis.

Focus groups are by no means perfect and Cohen et al. (2007) list several drawbacks: they do not produce quantifiable data, the number of people involved tends to be small and group dynamics may lead to non-participation by some members within the group. However, this was an exploratory study and we therefore concluded that the use of focus group interview was appropriate.

11.3.1 Procedure and Participants

We conducted three 45-min sessions of semi-structured interviews with the focus group; in each of the three sessions we recorded the audio. During each session, we asked the group a series of prepared questions, developed by us, based on general conceptions of mathematical creativity and, more specifically, creative contradictions. The questions were collectively directed at the focus group and became a starting point for discussions among the members on the specific subtopics of creativity and creative contradictions. We remained mostly passive during the discussions, only asking follow up questions to individual members or the group if there was something unclear or if we wanted the members of the group to expand further on a particular subject.

The focus group consisted of eight members, all of them teacher educators in mathematics. Three of the members were male and the age of the members of the focus group varied from 34 to 60. All of the group members had a formal educational background of a master's degree or PhD in mathematics or mathematics education. Participants in the focus group were selected based on volunteer participation in a larger group of 80 teacher educators participating in a conference on teacher education in mathematics.

11.4 Analysis

We first transcribed all of the recordings separately. Afterwards we compared the two transcripts and ironed out differences and uncertainties. In three instances, each about the length of a sentence, it was impossible to make out what the focus group member was saying and we therefore noted it to be unintelligible. After we had transcribed all of the audio recordings, we employed thematic analysis as the primary method for analysing the data. Thematic analysis is a method for analysing and reporting patterns and themes within data, organising and describing a dataset in rich detail (Braun & Clarke, 2006). The analysis can be characterised as a combination of an inductive and deductive process. An inductive approach implies that the themes are closely related to the data and not necessarily related to the specific questions. In contrast, a deductive or theoretical approach is driven by the researcher's theoretical and analytical interest in the area (Braun & Clarke, 2006). In this study, we used the idea of creative contradictions as a theoretical starting point for both the interview and the analysis. Based on this theoretical 'lens', presented in the section two, we coded the transcripts individually, before collecting the codes into potential themes. Finally, we compared the potential themes, discussed similarities and differences and jointly produced the final themes with appropriate names.

11.5 Results

We organised the results of this study into two main themes that were seen throughout the interviews. Each main theme, identified in the focus group interviews, was related to the topic of creative contradictions. Under each main theme, we present subthemes that helped us analyse and understand the main theme, by identifying specific and more tangible characteristics of the main theme. For each subtheme, we either present short examples of the teacher educators' statements on the subtheme or present slightly longer episodes, in which the subtheme was discussed. We present longer episodes when the context of the teacher educator's statement is important.

11.5.1 Theme 1: Mathematics as Rote Memorisation Or as a Highly Creative Field

One of the biggest differences between school mathematics and professional mathematics can be illustrated by focusing on the idea of creativity. Learners of mathematics often view mathematics as an exercise of rote learning, yet mathematicians describe their field as a highly creative endeavour. The participants in the focus group interviews mentioned several times that there was a difference between school mathematics and mathematics. We therefore probed further and asked why this is the case. We identified four different subthemes during the interview.

The first subtheme referred to the *teachers' mathematical competence*. The teacher educators stated several times that the teachers were the problem, because they lacked the necessary mathematical knowledge.

Teacher Educator 1 (TE1): "There are some teachers who get between the students and the mathematics… A lot of teachers don't think of mathematics as creative."

Teacher Educator 2 (TE2): "we as teacher educators or mathematicians might think that [mathematics is creative], but it is the teachers that teach the pupils."

Teacher Educator 3 (TE3): "the problem lies with the teachers, with the elementary teachers, because they don't have that [necessary] background. Now if I don't understand those things myself, if I couldn't apply them myself, how can I explain that something is viable?"

TE1 first introduced the idea that teachers themselves could be the cause of the apparent schism between school mathematics and professional mathematics in terms of creativity. TE2 then explicitly stated that the teachers were the problem. TE3 agreed with TE2, explaining that we, and mathematicians, may think that mathematics is highly creative, but students in school are taught by mathematics teachers, not mathematicians. Expanding on this issue, TE3 explained how mathematical knowledge influences teaching. Unless teachers have a strong mathematical foundation, they are not able to distinguish between viable and non-viable reasoning in mathematics. We also asked the rest of the focus group if anyone disagreed with the three teacher educators, but they all explicitly stated or nodded that they agreed with what had been said.

Closely related to the first subtheme, the second subtheme was *the relationship between knowledge and creativity*, in particular within mathematics. This subtheme became an extension of the first subtheme and the interview shifted focus from teachers' lack of knowledge to the relationship between knowledge and creativity in mathematics. Directly after the discussion on the teachers' lack of mathematical knowledge, the relationship between knowledge and creativity was raised. This short episode began with an explicit question from a researcher:

Researcher 2 (RE2): "How much knowledge or rote learning is necessary before you can be creative?"
Teacher Educator 4 (TE4): "Not that much."
Teacher Educator 5 (TE5): "You need some knowledge, but we're talking about two different things here. Rote learning is not wrong."
Teacher Educator 1 (TE1): "It is for your teacher students, or teachers to schoolchildren, they have to give them first a structure, a base to begin with so that they can build upon this. If there is creativity, it is upon that. Otherwise, if they don't have this, if they are not introduced to these things, we can't expect creativity at all."

The notion that at least some knowledge is necessary for creativity to arise is common throughout the literature (Weisberg, 1999). We, however, wanted to shift our focus from how much knowledge is necessary, to what type of knowledge is necessary for creativity to arise. We therefore asked what type of knowledge is necessary to be creative in mathematics:

Teacher Educator 6 (TE6): "Like what do you need…Higher courses are about definitions. How can you talk about something in topology, algebra or geometry if you don't have the definitions."
Teacher Educator 7 (TE7): "About rote learning and creativity… I have to know some concepts before I can solve a problem. I also need concepts before rules…but I also need rules. I need to understand the rules and concepts first."
Teacher Educator 8 (TE8): "There has to be a balance. You can't solve problems all the time. You have to make sure they [the students] learn the rules, learn the definitions and the mathematical language. If you don't have that, you can't be creative. I mean…You need to know the rules and definitions in order to be creative."

All of the participants in the focus group interview agreed that mathematical knowledge was necessary to be creative in mathematics, but they disagreed to some extent on what type of knowledge is necessary. TE6 claimed that, at least in higher courses of mathematics, it was not possible to talk about mathematics and be creative, unless the relevant definitions were understood. Both TE7 and TE8 went further and said that the students need both rules and concepts before they can solve problems and be creative. TE8 also stated that students need to learn and understand the mathematical language in order to be creative.

The third subtheme is related to the nature of school mathematics and mathematics in itself. The teacher educators explicitly drew *a line between mathematics and computation*, highlighting the importance of the latter in school mathematics. The following episode was prompted by a question by a researcher:

Researcher 1 (RE1): "Is this true in your experience? That, for instance, teacher students see mathematics as rote memorisation, while mathematicians see it is a creative field?"
Teacher Educator 4 (TE4): "Are we talking about the same thing? Is this mathematics or is it computation?"
Researcher 2 (RE2): "What do you mean by that, computation or mathematics?"
Teacher Educator 4 (TE4): "OK, most of school mathematics is computation and computation can be translated into rules, then it becomes easy for the teacher and we've already talked about rules of thumb. Mathematics may be something different and text books are mainly focused on closed computation tasks. There isn't much puzzling or creativity."

During this small exchange, at least four of the other teacher educators expressed their explicit agreement by nodding or saying they agreed. In the first subtheme, the teacher educators pointed to the teachers themselves as being the cause of this schism between school mathematics and professional mathematics. In this subtheme, the cause is shifted from the teachers' lack of knowledge, to the school subject itself. TE4 is the first to bring up the view that there is a difference between mathematics and computation, then elaborated and explained that school mathematics is mostly computation, pointing to the contents of textbooks as an example of this. Two of the participants disagreed and claimed that the nature and content of school mathematics opened up more opportunities for creativity than higher level mathematics courses:

Teacher Educator 6 (TE6): "It depends on the [grade] level. In school mathematics you can illustrate equations using weighing scales. How can you teach like that in algebra…at the university level?"
Teacher Educator 7 (TE7): "How do you teach creativity at the university level…With 100…200 students?"

Although there is a difference between higher/university level mathematics and professional mathematics, both comments help shed light on the teacher educator attitudes towards the nature of school mathematics and creativity. Taken together, these two statements indicate that teaching for mathematical creativity depends on the number of students in the class and whether or not mathematical ideas can be represented and/or illustrated using familiar objects and concepts.

We called the last subtheme we identified *expectations.* This subtheme was identified based on what the teacher educators had said about both student and teacher expectations in school mathematics:

Teacher Educator 4 (TE4): “I think a lot of teachers would say that they don’t have time to enquire. We need quantity, not quality. It’s too scary to just do a few problems. We have to do as many problems as possible.”

Teacher Educator 1 (TE1): “Many teachers give students very little time to think. And just the clever ones who are coming very fast with the answers are having fun and those who need more time don’t get that time.”

Teacher Educator 4 (TE4): “We [teachers and students in the classroom] have to do as many tasks as possible. Do as much computation as possible… What do we assess on tests? We assess computation.”

In these excerpts, we see how the expectations of teachers influence school mathematics. Teachers are expected to prepare students for formal and standardised testing and, because tests often focus mostly on computation and skill (see, for instance, de Lange, 2007), school mathematics therefore becomes heavily focused on skill practice and computation. Two of the teacher educators also mentioned that students’ past experiences shape their expectations which, in turn, influences how teachers teach school mathematics:

Teacher Educator 4 (TE4): “I think it has to do with expectations. What you’ve experienced yourself. If you experience something that is in conflict with what you expect, there is some resistance.”

Teacher Educator 3 (TE3): “I think it’s difficult when the students begin lower or upper secondary school and then experience a non-direct instruction based type of teaching. You have to start at the beginning, so that the students become used to participation in mathematics classes.”

Students are not used to open-ended problems and enquiry-based learning in school mathematics. TE4 and TE3 speculated that this, in turn, could influence how teachers, especially in lower and upper secondary, teach mathematics. Therefore, students display cognitive resistance to the type of teaching necessary for creativity and teachers might resort to traditional, skill-based teaching.

11.5.2 Theme 2: What Is Mathematical Creativity?

We called the second theme: “what is mathematical creativity?” The reason we formulated this as a question was the fact that this question was explicitly raised, unprompted, by the teacher educators several times during the interviews. The discussion on the nature of mathematical creativity helped us both further understand the teacher educators’ views on mathematical creativity and placed the previous main theme within a larger context. The schism between school mathematics and professional mathematics in terms of creativity, necessitated further investigation of mathematical creativity itself. We identified four subthemes of this main theme.

The first subtheme was a recurring discussion on *creativity as a product or as a process*. Plucker and Beghetto (2004) offered an empirical definition of creativity based on a literature review of earlier research: “the interplay between ability and process by which an individual or group produces an outcome or product that is both novel and useful as defined within some social context” (p. 156). This constant tension and interplay between process and product was mentioned several times. The following excerpts are from a discussion on a specific mathematics problem given to them:

Teacher Educator 7 (TE7): "This is a creative task… because here is not just one solution. One solution that everyone will kind of agree on."

Teacher Educator 3 (TE3): "I guess I feel creative is more like an adverb than an adjective. In a way that it's what you're doing that is creative but a thing is not creative in itself. Creative is not used to describe a thing, it is used to describe an activity."

Teacher Educator 5 (TE5): "Creativity lies in the arguments. Behind solutions."

Teacher Educator 8 (TE8): "But is it the task that is creative or is it the way we work on it? And how are there connections between them?"

Teacher Educator 4 (TE4): "But I think it is difficult to say that a task is creative. It's more because I feel like creativity is more connected to people than to something written on paper."

The teacher educators disagreed whether or not a mathematics task was creative in itself. TE7 said the task was creative because it did not only have one correct solution. This statement led to a discussion on the interplay between creativity as a process and as a product.

Teacher Educator 4 (TE4): "So I kind of feel that if people are engaged then there is creativity. So you can give a task to one class, and for them it will not have any creativity because it doesn't engage them. And then you can give the same task to others and they will get really engaged in it and you get a lot of creativity."

Teacher Educator 5 (TE5): "The crucial point is how the pupils or students are presented with the task and what the focus of the teachers is. In much mathematics, many teachers give students very little time to think and so the clever ones are coming very fast with the answers and are having fun and those who need more time don't get that time and then they can even feel miserable and can't even join in the reasoning about the solutions and everything."

TE4 and TE5 offered some further insight into how the teacher educators view the relationship between creativity as a process and as a product. The characteristics of the task itself are not sufficient to stimulate a creative process in the classroom. Both TE4 and TE5 said that it is also important to present the task in a way such that the students become engaged and are provided with sufficient time to think about and work on the task.

Based on the teacher educators' statements on the interplay between process and product, we wanted to know if they view *creativity as a means to an end or as goal in itself*. The following episode then occurred:

Researcher 2 (RE2): "Is creativity a goal or a means to some other goal?"

Teacher Educator 3 (TE3): "Both."

Teacher Educator 8 (TE8): "When I see students experience that joy of solving a problem for the first time… it could be solving a problem or just an equation for the first time. Creativity is more in the background. It's the joy of understanding something that is important."

This was then followed up by TE2 who told a story about a boy in second grade who was asked to make a triangle on their desk using their pencil, but without drawing anything. The student then placed his pencil in the corner of his desk, outlining a triangle. TE2 highlighted the fact that the student was not very good at computation-based tasks. This led to the following response from TE8:

Teacher Educator 8 (TE8): "The interesting thing here is… would that develop his ability in mathematics?"
Teacher Educator 2 (TE2): "I think that you have learn how to be unafraid. You need to learn how to face new challenges."

The teacher educators had mixed views on creativity as a means to an end or a goal in itself. TE3 said that creativity was both a goal in itself and means to a (different) end. TE8 explicitly said that the goal was mathematical understanding and creativity could work as a means to achieve a deeper understanding. TE2 then told the story about the boy in second grade who was asked to make a triangle. Both TE2 and TE8 then focused on creativity as a means to achieve a goal. The difference of opinion between the two teacher educators was the purpose of the activity. TE8 focused on mathematical ability, while TE2 focused on mathematical attitudes and beliefs. We then asked the teacher educators about the relationship between ability and creativity in school mathematics. The following episode was classified as its own subtheme, called *mathematics and creativity*:

Researcher 2 (RE2): "Can you be a high achiever in mathematics without being creative?"
Teacher Educator 2 (TE2): "Yes, in Norwegian school. Those are the winners. Those who aren't creative. If you are too creative, the teacher doesn't understand."
Researcher 2 (RE2): "Can you be creative in mathematics without being a high achiever?"
Teacher Educator 2 (TE2): "Yes, when the teacher doesn't understand the students' thinking."

In this episode, the teacher educators differentiated between mathematical achievement and mathematical creativity. TE2 explicitly stated that there are those who are high achievers in school mathematics, but not creative, and vice versa. Several of the other teacher educators explicitly nodded or agreed with these two statements. It therefore seems as if the teacher educators view mathematical creativity and mathematical achievement in school as two different concepts. Sriraman (2005) claims that mathematical creativity in a K-12 setting is seen as on the fringe of giftedness. Mathematical knowledge/achievement is a necessary but not sufficient requirement for mathematical creativity.

We therefore wanted to know what the teacher educators thought regarding whether or not mathematical creativity could be learned or if it was an innate ability:

Researcher 2 (RE2): "Professional mathematicians… are they born creative or have they learned to be creative?"
Teacher Educator 1 (TE1): "Everyone can learn it."
Teacher Educator 8 (TE8): "That is not clear. It's difficult to say. I mean, creativity is not a clear concept. It's a bit here and there."
Teacher Educator 2 (TE2): "But we see those (who are creative) as not being imitative. If we stimulate children and want creative children instead of monkeys,[1] we get creative children."

[1]The term monkey, or 'apekatt' in Norwegian, has a similar meaning to the English term 'copycat'.

Teacher Educator 3 (TE3): "Everyone can become more creative, but we have different abilities."

Teacher Educator 3 (TE3): "Everyone is born creative in some way. It doesn't have to be mathematics. The person has this ability…this creativity in themselves."

Teacher Educator 8 (TE8): "There is a difference… You can be an artist…paint, without knowing any mathematics."

In this episode, the teacher educators expressed two ideas related to the theme of mathematics and creativity. The first, and important, idea is that everyone can learn to be more creative. This is important because it implies that school mathematics can stimulate and improve student mathematical creativity. The second idea is that creativity is domain specific, but dependent on a general ability as well. The idea that creativity depends on both a general ability, but also knowledge and abilities within a specific domain, is also seen in the literature (Baer, 2010).

The last subtheme we identified was *creativity as flexible and original reasoning*. Throughout the literature (see, for instance, Haylock, 1987; Runco, 2008; Lithner, 2008; Haavold, 2011) flexibility and originality are seen as two key characteristics of creative reasoning.

Teacher Educator 3 (TE3): "Creativity is about dealing with new situations. Solving a problem you haven't seen before, thinking flexibly. Creativity is solving new problems, flexibility and dealing with new situations."

Teacher Educator 2 (TE2): "You have to be unafraid. Meet challenges and not think that I can't do this. You need confidence to attack the problem. You have to be able to think flexibly and not just remember."

We see that both TE3 and TE2 mention flexibility and originality as two characteristics of creative mathematical thinking.

11.6 Discussion

In this exploratory study, we sought to answer the following research question: "What are teacher educators' conceptions of mathematical creativity?" We conducted a series of focus group interviews with teacher educators and analysed the data using thematic analysis in order to answer our research question. The first main theme was called *Mathematics as rote memorisation or as a highly creative field.* Students often experience mathematics as a rule-based exercise, with little room for imagination, while mathematicians describe their field as a creative endeavour. Based on the data from the interviews, we identified four subthemes that help explain this apparent difference. We termed the first subtheme *teachers' mathematical competence.* TE1 first brought the group's attention to teachers themselves as an explanation for the ostensible divide between school mathematics and mathematics. This idea was reinforced by the other teacher educators, who agreed that school mathematics is mostly rote memorisation and skill-based, due to the fact that the teachers themselves do not see mathematics as a creative field. The teacher educators furthermore stated that the reason was that teachers lack the necessary mathematical knowledge. We found it interesting that the teacher educators did not differentiate between beliefs about mathematics and beliefs about mathematics instruction, as Collier (1972) did in his study of teacher beliefs. It is possible to, for instance, hold the opinion that higher level mathematics is a creative endeavour, but that school mathematics is best taught using direct instruction.

The teacher educators did not delve further into the characteristics of the relationship between mathematical knowledge and mathematical creativity. We therefore wanted to investigate further the nature of the *relationship between knowledge and creativity.* The teacher educators all agreed that some knowledge is necessary to be creative and solve problems. Taken together, the teacher educators' statements reveal at least two interesting positions. Firstly, the teacher educators hold a very traditional view on mathematical knowledge and problem-solving (and creativity). Lesh and Zawojewski (2007) provide a model that helps us understand the teacher educators' views. In their model, the traditional view of problem-solving posits that learners first acquire concepts, skill and strategies, and only in the final stages of instruction are they engaged in complex and challenging problems. Problem-solving is not equivalent to mathematical creativity, but they are closely related. The teacher educators often used the two terms interchangeably, as solving problems is often the activity of mathematical creativity. The alternative view to the traditional view is that learning of mathematical knowledge takes place through problem-solving (Lesh & Zawojewski, 2007).

This model of traditional and alternative view of problem-solving can also shed some light on the first subtheme. The teacher educators believed that teachers' lack of mathematical knowledge is the reason school mathematics is not experienced as a creative activity. However, it is possible that the mathematics teachers in school hold the same views on problem-solving as the teacher educators themselves. Mathematics instruction in school might be based on rules, rote learning and direct instruction, if the teachers believe that their students first must acquire a strong knowledge base before they can solve problems and be creative.

The second position is related to the type of knowledge required to be creative in mathematics. The teacher educators mentioned several different strands of knowledge they thought was necessary to be creative, ranging from definitions, via concepts, to rules and the mathematical language itself. In our opinion, this is an interesting topic for future research in both mathematics education and creativity research in general: investigate further the relationship between different strands of mathematical knowledge and how they influence mathematical creativity.

A third reason for the gulf between school mathematics and higher level mathematics was, according to the teacher educators, the nature of school mathematics itself. We called this subtheme *a line between mathematics and computation.* TE4 stated that school mathematics, in particular text books which strongly influence school mathematics, are mainly focused on closed computation tasks. Goals for mathematics instruction depend on one's conception of mathematics. If mathematics is seen as a body of facts and procedures, then mathematics is seen as having mastered these facts and procedures. In turn, school mathematics is essentially rule-based computation. On the other hand, if mathematics is seen as the 'science of patterns', then problem-solving and creativity become an essential aspect of school mathematics (Schoenfeld, 1992). Based on the teacher educators' statements, we conclude that they think school mathematics is mostly seen as a body of facts and procedures that are to be mastered.

We named the last subtheme *expectations* and it points to how expectations shape school mathematics both for teachers and students. Teachers are, for instance, expected to prepare students for the high stakes testing that has an impact on the students, schools or both. School mathematics could therefore be mostly focused on rote learning as standardised tests often focus mostly on procedural skills (de Lange, 2007). This phenomenon has been named WYTIWYG – "What You Test Is What You Get". The underlying assumption is that assessment reforms not only impacts assessment, but also the curriculum and the instruction that students receive. However, Wilson and Carstensen (2007) claim that this is not the case, as reforms rarely lead to change in instruction in the classroom. We therefore find it unlikely that the expectations of standardised tests are the reason school mathematics is mostly focused on procedural skills.

Students' expectations might also influence classroom instruction in school mathematics. After years of being told everything they need to know by their teachers, the students might resist if this support is suddenly withdrawn. In a problem-based learning environment, the student would have to take a more active role in their learning process. When confronted with the need to take more responsibility for their own learning, students might protest (Felder & Brent, 1996). Their past experiences have shaped their expectations, which in turn influences school mathematics.

All four subthemes help us understand why, at least according to teacher educators, professional mathematicians say that mathematics is a creative field, while learners experience school mathematics as mostly skill-based practice. However, as TE8 pointed out, creativity is not a clearly defined concept, at least in the context of the focus-based interviews. We therefore needed to clarify the idea of mathematical creativity further, in order to better understand the relationship between school mathematics and higher level mathematics.

To clarify the concept of mathematical creativity of the focus group, the second theme of the analysis asks the question *what is mathematical creativity*? The first subtheme under this heading reveals the participating teacher educators' conceptions of the interplay between process and product. TE3 makes the point that creativity is what you are doing, not a thing. TE8 asks if it is the task, or how we work on it. This means that the teacher educators relate creativity to a process.

However, they seem to disagree on the question as TE4 points out that one task can be creative to one group of students, yet the same task might not work as a creative task to another group of students. Furthermore, TE7 characterises a task as creative because it has several solutions. If TE7 meant the ability of a person to think of several solutions to the task, this would have been divergent thinking (Haylock, 1987). However, this indicates that the teacher educators also relate the concept of creativity to a product.

Under the subtheme *mathematics and creativity* the teacher educators discuss who can be creative. TE2 makes the point that in Norwegian schools it is possible to be a high achiever without being creative. TE2 also points out that students can be creative in mathematics without being a high achiever. TE3 makes the statement that everyone is creative in some way. Thus, the teacher educators also relate creativity to a person. This also means that TE2 touches upon the difficult question of the relationship between excellence and creative potential in mathematics.

Leikin and Pitta-Pantazi (2012) carried out a literature review of creativity research and found that the focus is either on the creative person, the creative process, the creative product, or the creative environment. The teacher educators participating in the discussion of this study appear to have the same focus as creativity researchers have, except for the focus on the creative environment.

Under the subtheme *mathematics and creativity*, TE3 makes the point that everyone is born creative in some way, whereas TE1 states that everyone can learn it. When TE1 makes this statement, it is a response to the question whether professional mathematicians are born creative or have to learn to be creative. Therefore, it is not clear if the statement of TE1 applies to people in general or just professional mathematicians. The statements of TE1 and TE3 do not have to contradict each other of course, because people can probably be born with a creative potential and then develop their creativity through a learning process. TE3 gives a statement in support of this point of view when expressing that everyone can be more creative.

Under the same subtheme, TE3 makes the point that everyone is born creative in some way but not necessarily in mathematics. TE8 follows this up by stating that there is a difference because one can be an artist without knowing any mathematics. It appears that TE3 and TE8 are making statements about the question if someone can have multi-creative potential, though they are perhaps not very clear about it.

Some of the discussion revealed that the teacher educators have different focuses on creativity such as process, product or person, but some of the discussion revealed the participating teacher educators conceptions of the meaning of creativity. Under the subtheme of mathematics and creativity TE2 points out that the creative ones are those not being imitative. TE2 further states that children can be stimulated not to develop into copycats. However, one could argue (Birkeland, 2015) that not being imitative does not qualify for creativity because it is possible to reason flexibly but still not have novelty.

The last subtheme called *creativity as flexible and original reasoning* has interesting statements by two of the teacher educators. TE3 makes the point that creativity is about dealing with new situations and flexible thinking, and TE2 points out that creativity requires confidence and flexibility, not just memory. Originality or novelty is a key element in the concept of creativity by most creativity researchers. Flexibility is a term attached to Haylock (1987). Thus, the points of view of TE2 and TE3 accord with much of the research.

It is interesting to ask teacher educators questions about their conceptions of mathematics and creativity because their conceptions might have an impact on their teaching, which, in turn, might have an impact on the future teaching of pre-service teachers. Whether pre-service teachers conceptions of mathematics includes creativity remains an open question (Lithner, 2008).

As indicated by the analysis, students often view mathematics as a matter of rote learning, while for mathematicians, conceptions of mathematics include creativity. This contradiction might perhaps also find an explanation in different conceptions of mathematics itself. At a philosophical level, one may ask if mathematicians discover or create mathematics.

Regarding the foundation of mathematics, Platonism is the position that mathematical objects are real. Their existence is an objective fact quite independent of our knowledge of them (Davis, Hersh, & Marchisotto, 2003). According to this position, mathematicians discover mathematics rather than create it. If mathematicians discover mathematics, one might ask if this involves any creativity at all.

However, to discover mathematics might perhaps involve creative processes. According to Platonism, the existence of cubic equations and their solutions is an objective fact independent of our knowledge of them. The mathematicians of the renaissance, such as Girolamo Cardano (1501–1576) discovered the solutions of cubic equations as real objects. However, one could argue that discovering the solutions of cubic equations they had to invent or create the complex numbers. Therefore, one might argue that even though mathematicians discover mathematics as real objects, the discovery might involve creativity.

Platonism is one possible standpoint, another one is formalism (Davis et al., 2003). According to formalism, there are no mathematical objects. There are strings of symbols and certain rules for working on these symbols but they have no meaning. Therefore, it might be more natural to think that mathematicians create mathematics with a philosophical position like formalism.

Sriraman (2009) characterises the work of professional mathematicians as creative. Whether students' conceptions of mathematics includes creativity is less obvious. If students' mathematical understanding is instrumental rather than relational (Skemp, 1978), then they probably associate mathematics with rules and procedures. Thus, if students have an instrumental rather than a relational understanding of mathematics, then it is difficult to see how creativity can be part of their conception of mathematics. If, on the other hand, students have a relational rather than an instrumental understanding of mathematics, then learning mathematics would centre on concepts and structures and not rote learning. However, the question whether students with a relational understanding of mathematics include creativity as part of their conceptions of mathematics needs further study.

In this study, we found two main themes and eight subthemes of mathematical creativity that are seen throughout the literature. We contend that these findings are related to the nature of mathematics and mathematics instruction. Furthermore, they reveal a conceptual contradiction in the teacher educator's conceptions of mathematics and mathematics education. According to the teacher educators, mathematics is, at least to some degree, a creative field in which mathematicians solve authentic problems. However, the teacher educators preferred a traditional view of mathematics education, in which learners first acquire concepts, skill and strategies and then solve problems. Now, it is possible to conceive mathematics as a science of patterns and still prefer traditional direct instruction. Still, we would expect a strong connection between epistemological views of mathematics and didactical views of mathematics instruction. If mathematics is seen as a creative, pattern-seeking science, then solving problems should be central to learning mathematics.

There are some limitations to our findings as they are based upon statements from eight teacher educators during semi-structured focus group interviews. We do not make any claims about the prevalence of these conceptions and we do not know whether the teacher educators' behaviour follows their beliefs and conceptions. It is possible to say and think one thing, yet do something completely different. In order to address these two main limitations, future research would have to investigate larger, random samples of teacher educators and observe how the teacher educators teach mathematics themselves.

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Chapter 12
Do We Need a Revolutionary Approach to Bring Creativity into Education?

Cynthia A. Burnett and Kathryn P. Haydon

Abstract What would it take to build an educational system that truly integrated creativity into the core of its processes? In this chapter, we will explore two different approaches to changing the system. We will look at the idea of an educational revolution, and, in particular, the trajectory of the Quiet Revolution that Torrance EP, Goff K (1989) J Creat Behav 23(2):136–145 discussed in their paper of the same name. In contrast, we will look at what the theory of evolution might tell us about changing a system through a more gradual process.

12.1 Introduction

In 1989, Torrance and Goff wrote a paper entitled, "The Quiet Revolution." The paper outlined what they saw as the paradigm shift that had occurred in educational theory and practice. They identified changes in teaching materials, teaching practices, and even the physical teaching environment. The paper posited a bright future for educational systems and a real shift toward educating children in a style that valued and nurtured their creativity skills.

However, in 2011, Kim published "The Creativity Crisis," a review of student scores on the Torrance Test of Creative Thinking (TTCT) since 1990. Overall, student creativity scores, as measured by the TTCT, had dropped significantly during the previous two decades. More precisely, from 1990 to 2008:

- the decrease in fluency scores was significant;
- the decrease in originality for kindergarteners through third graders was significant;
- the decrease in elaboration was significant; and
- the decrease in creative strengths was significant (Kim, 2011).

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While the TTCT is only one measure of creativity, it leaves us with the question, what happened to the creativity-in-education revolution that seemed to be gaining ground in the 1980s? Was it crushed, did it fizzle, or was it just an illusion?

12.2 The Future Is Here Already – It's Just Not Evenly Distributed

Just as averages in research studies don't tell us anything about specific people, the overall state of the U.S. educational system doesn't describe individual schools. In fact, Torrance and Goff's (1989) view of the transformation of schooling toward creative learning did become a reality in a relatively small number of locations.

These revolutionary locations fall into various categories. Most are private and independent schools, some are charter schools, and a small number are public schools – typically schools for the gifted and talented – that have embraced methods designed to enhance students' creativity skills. Of course, many more 'locations' are simply parents who have left the school system entirely, choosing to educate their children at home. The Quiet Revolution had supporters, but the vast majority of the educational system declined the opportunity to incorporate creativity skills and headed off in a completely different direction.

But what caused this split? Some researchers identified the move to standardized education as the key force that directed mainstream education away from the path of creative educational practices (Beghetto, 2010; Longo, 2010). In essence, we support this view, but we would like to explore the impact of standardized education in more detail. We believe that this is important because the core objective of standardized education is to raise the quality of education for all and reduce the likelihood of the least privileged students falling through the net. We believe this goal is laudable and should be supported. Unfortunately, the move to standardization has had a range of unintended consequences, one of which appears to have been the significant reduction in the probability that creativity will be nurtured in the classroom (Beghetto, 2010; Richards, 2010; Torrance, 1959). Furthermore, students in low-income areas are the most likely to be negatively affected by this shift (Beghetto, 2010).

But what is it about standardization that has created this impact? We suggest three distinct and interrelated factors: testing, content expansion, and the system's reaction to creative behaviors.

12.3 Is Testing to Blame?

> I stood in the hallway with the head administrator of a local inner city charter school. He was sharing with me his frustrations around student engagement. "Let me help you," I entreated him. "I can show your teachers how to use creative learning methods to increase student engagement."
>
> "That would be great," he replied. "Unfortunately, the only thing that is going to keep us open is the numbers on the standardized tests. I don't need them to be creative. I need them to know how to choose the correct answer."

The standards-based reform movement began in the 1980s as a way to identify the information students should know at any given grade level (Jennings, 2012). The objectives included providing equal education opportunities to all students and raising the overall level of performance (McClure, 2005). Raising performance is typically defined by increasingly high scores on tests that don't account for creativity. With the onset of the No Child left Behind Act in 2002, standardized education began to take on a new meaning. Increasingly, the focus became teacher accountability for student test scores. This created a culture of test-driven reform, rather than educational reform (Jennings, 2012). Instead of finding ways to engage students in meaningful learning experiences, teachers were trying to find ways to infiltrate content knowledge and teach students information with the primary goal of passing the test.

So where does creativity fit in with testing? How can we expect students to generate original and useful ideas when they have been trained that there is one right answer? As Longo (2010) pointed out:

> Standardized testing remains a contentious issue in education today, and many argue that it weakens creativity. Scores generated by state assessments are used for political purposes to compare students, institutions, and teachers. Standardized testing has always had a major impact on education, but it now impacts… area[s] in which students have opportunities to display creativity. (p. 55)

Government policies are fairly blunt objects. The authors of any piece of legislation are typically trying their best to achieve an effect across an entire system, which means that the policies are likely to be partly wrong for everyone involved in the system. As the system begins to involve more people, this effect is exacerbated. In the U.S., we have moved from individual districts and communities working to meet the needs of their own students, to states setting the standards, and now, to the federal government establishing standards for every state and community. As the directives and correlative assessments have become more centralized, there is less flexibility for individual districts and schools to meet the specific needs of their own communities.

For example, one public school with whom the second author on this paper has worked has a student population comprised mostly of students whose first language is Spanish. Many of the students had no experience speaking or hearing English before entering the school. The school is brimming with creative energy, led by the exceptionally dedicated principal. Classrooms are vibrant, children are engaged, and creative learning is occurring. When asked about standardized testing, the principal smiles. “The tests don’t work for our population. We don’t put much weight on these tests because they don’t tell us anything about what our students need. Instead, we have developed our own processes and measurements, and we are seeing steady growth in our students. We have a major focus on creativity.” This school has a certain flexibility that many schools don’t have, because it would be detrimental or impossible to “make” the students take the tests “correctly,” when it is known that they are likely to score poorly for reasons beyond their control. On state rankings, the school would not be highly ranked in terms of standardized test scores. But the experience one has while visiting is in stark contrast to the strict atmosphere in one of the “best” public schools in a more elite area across town. This example illustrates how central government-directed standards often miss the boat for many in the system because of the distinct needs of schools, communities, or regions of the country. Sadly, the move to standardized testing has deflected educators’ attention from meeting individual needs through creative learning, as described by Torrance and Goff (1989), to training students in successful test-taking. The goal of ensuring that the least privileged children are receiving top education is not working if the schools with these children have to deliberately work against the system to support their students.

12.4 Did Content Kill Creativity?

> Technically, there is not enough time to implement all of the curricula that I am supposed to be teaching. Each day, I have to make a forced choice of what I can cut. I have to shave minutes off their playtime because there is just so much to cover. – Kindergarten Teacher

An additional impact of the testing/teacher evaluation combination can be seen in elementary education. To raise test scores, schools have attempted to teach more content, at a higher level, to their elementary children. Given that we have no evidence that modern students learn faster, the result of this change has been to squeeze out other activities to find time to accommodate the additional material. For example, when we look at early childhood education, we see recess and free play being reduced or even eliminated. Studies (cited in Miller and Almon, 2009) have found that:

- Teacher-directed activities, especially instruction in literacy and math skills, are taking up the lion’s share of kindergarten classroom time.
- Standardized testing and preparation for tests are now daily activities in most of the kindergartens studied.
- Free play, or “choice time,” is usually limited to 30 min or less per day. In many classrooms, there is no playtime at all. (p. 25)

In the case of early childhood education, we know that play provides children with the opportunity to problem solve, imagine new ideas, and explore a range of possible answers (Ginsburg, The Committee on Communications, and The Committee on Psychosocial Aspects of Child and Family Health, 2007). These behaviors are essential for the development of creativity skills. Solving unstructured problems becomes ever more important as one moves upward through the educational system and into the "real world." Having domain knowledge is important, but so is having the time to integrate and explore that knowledge. As children get older, they still need play, but the play takes on different forms. When students have the opportunities to experiment, explore, invent, development, theorize, and make connections in content areas, they are being provided with the types of play and creative learning that are important for the development of problem solving skills.

12.5 Is the System Allergic to Creativity?

> "You teach creativity? I am not creative." – Teacher
> "Why would you say that?" – Creativity Professor
> "Because I am terrible at arts and crafts work." –Teacher
> "Have you ever had a student that had an issue you didn't know how to solve? And were you able to solve it?" – Creativity Professor
> "Of course. Every day I have a challenge like that!" – Teacher
> "Then every day you are creative." – Creativity Professor

Of course, the creativity research community must accept some responsibility for reactions such as the one in the conversation above. Over 50 years ago, Stein (1953) published the paper in which he offered what is now generally accepted as the standard definition of creativity—the generation of novel and useful ideas. However, researchers continue to develop new and often more expansive definitions (as discussed in Runco and Jaeger, 2012). While we strongly support the advancement of the field and understand that definitions are important building blocks on which to construct new theories, it is also the case that the plethora of definitions confuses the teaching community. This problem is amplified by the fact that both teachers and administrators are pressed for time and judged by other criteria. In essence, we as a research community have done a poor job of offering simple, practical guidance to the teaching community. Very few publications (Beghetto, Kaufman, and Baer, 2014; Burnett and Figliotti, 2015; Piirto, 2014; Torrance, 1979a) answer the question, "What should I do during first period on Monday morning that will strengthen my students' creativity skills?" Fortunately, there has been crossover work in the field of gifted education that addresses how to integrate creativity into classroom practices while teaching content (for example, see Smutny, 2009; Smutny, Walker, and Honeck, 2016). In fact, right around the time of the Quiet Revolution paper, Torrance and Safter (1990) wrote that they felt that the move toward creative learning was finally here to stay because of the work that had been done in gifted education:

> …the one thing that I think has made the difference has been the gifted education movement. The minority of people in the movement recognized that the one characteristic common to those who have made breakthroughs in all fields is their creativity; these people have made the difference. In my opinion, this minority has gradually become the majority. Gifted

> education has nurtured the creativity movement until it is now shared by all areas of education. (p. 3)

Unfortunately, this transition from gifted into mainstream didn't happen on a systemic level, and this is where we must examine the reaction of the mainstream teaching community. There is evidence (Scott, 1999; Westby and Dawson, 1995) that teachers see creativity as being associated with disruptive behavior. In a period during which teachers have to cover more content to achieve higher test scores, actively encouraging students to engage in (seemingly) disruptive behavior is unlikely to be a popular option. Any move toward a more creative learning environment is likely to result in more 'disruptive' – that is to say, creative – behavior. Fortunately, researchers Kaufman and Beghetto (2013) introduced the idea of *appropriate creativity*. This provides us with language for talking about creative thinking as a positive set of skills that contribute to learning when framed within the appropriate context.

The educational system is not averse to the development of creativity, but it does have legitimate concerns that make it harder to integrate creativity within its existing processes. Furthermore, there is still a significant issue around providing clear definitions and guidance to practicing teachers so that they can understand what is required of them.

12.6 Is Revolution the Answer?

> "You keep using that word. I do not think it means what you think it means."
> - Inigo Montoya, "The Princess Bride"

Educators are caught between the proverbial rock and hard place. On the one hand, state and federal policymakers are placing educational staff under increasing pressure to achieve acceptable test scores. On the other hand, researchers, industry representatives, and the same state and federal policymakers are demanding that the educational system equip students with a range of twenty-first century skills (Adobe, 2014; National Center on Education and the Economy, 2008; Partnership for 21st Century Skills, 2008; Trilling and Fadel, 2009). One of these frequently cited skills is creativity. Given these seemingly conflicting demands, it wouldn't be surprising if it were the teachers themselves who demanded the revolution. But irrespective of who plays the role of the revolutionary, one must ask what this alternative, "revolutionary" future would resemble.

12.6.1 What Would an Educational Revolution Look Like?

One doesn't have to look far to find people who claim to be engaged in an educational revolution. The internet has enabled some extraordinary improvements in content delivery. The Khan Academy freely streams hundreds of thousands of hours of content to students around the world. Additionally, adaptive software allows sites like the Khan Academy or programs like ALEKS to differentiate their teaching so that the pace of delivery adjusts to the needs of individual students. These examples are novel in some ways and will likely be part of the educational future. But are they revolutionary? Your local librarian might disagree. Free access to knowledge has been available – in some parts of the world – for a long time. The internet undoubtedly nudges this towards ubiquity, but the aforementioned examples do not make up the type of revolution that builds creative thinking skills; instead, they represent new delivery methods for traditional content. Furthermore, we can already see these types of resources being absorbed by the existing educational system. This is one more piece of evidence suggesting that these tools are supporting the current model, which is not a criticism, simply an observation. After all, over time many revolutions end up looking remarkably like the vanquished regime.

What about other seemingly revolutionary approaches to education? Recently, a number of Silicon Valley luminaries have become interested in education. Significant sums have been invested into organizations such as Alt School. Unlike the Khan Academy, Alt School focuses on individualized learning, using iPads and adaptive software, delivered to children in specific physical locations. Class sizes are small, and teachers are presented as learning facilitators rather than instructors.

Is such an organization an indicator of future trends? We would have to dig deeper into the full range of content and learning experiences provided to understand if this type of alternative is truly revolutionary. However, without a significant shift in the depth or nature of content and learning approaches, a scenario where children sit in brightly colored rooms working on iPads to complete personalized assignments specified by teachers may not fit the definition of revolutionary. Even so, an Alt School-type model, at the very least, could make incremental improvements to the immediate experiences of children who find themselves attending school at this juncture of tightened educational practices in the mainstream system. Though this particular solution is taking place in the private sector, we need to take all types of alternatives into consideration in order to test models that ultimately lead to broad-sweeping change.

While technology can be useful in tailoring standardized content toward an individual learner's pace and style, it doesn't always encourage a deeper level of creative thinking. If the internet and its associated software aren't providing a revolution, do truly revolutionary examples of educational systems actually exist? The "democratic schools" offer an entirely different way of structuring education. The Sudbury Valley School is an example of this approach. At Sudbury Valley, the entire structure of the educational process is developed as a partnership among the stakeholders, students included, with the central premise that "each person is responsible for his or her education" (Gray, 2013, p. 91). In addition to the philosophy of personal responsibility, there are several tenets that differ from traditional schooling:

1. There are no curricula or requirements;
2. Students are not grouped by age and are free to associate with others of any age, including adults; and
3. The school is governed by its community members who choose to participate in the governance (Gray and Chanoff, 1986).

It is run by a School Meeting,

> which includes all students and staff members and operates on a one-person-one-vote basis, regardless of the person's age. This body, which meets once a week, legislates all rules of behavior, hires and fires staff, makes all major decisions about budgetary expenditures, and in general has full responsibility for running the school. (Gray, 2013, p. 89)

Sudbury Valley was founded in 1968, so there have been ample decades to track and study the graduates of the school over time. The growing body of literature (see, for example, Gray, 1993; Gray and Chanoff, 1986; Gray and Feldman, 1997) around this model typically concludes that "graduates have continued to do well in higher education and in their careers, and the great majority of them attribute much of their success to the skills, attitudes, and values they acquired during their years at the school" (Gray, 2013, p. 97).

Do the democratic schools represent the creative learning revolution? On the face of it, they do. Although the term *democratic school* encompasses a number of different types of schools, most of them share principles that come from a radically different philosophy. Democratic schools completely change the power dynamics within the structure, which theoretically allows learning experiences to be meaningful to an individual student, having been driven by that student's choice. This opportunity has offered a potentially life-changing benefit to students who rebel against the coercion, control, or unimportant work they feel they have faced in traditional schools. The freedom that students are given at Sudbury allows them to find what is meaningful to them and, ultimately, move on to success in college and in life (Gray, 2013; Gray and Chanoff, 1986). Gray (2013) wrote, "People who had rebelled against required schoolwork when they had no choice in the matter, before going to Sudbury Valley, were not rebelling against the requirements of college and jobs because these had been their own choices" (p. 95). This supports the idea that meaning is a primary component of creativity, and it is a step in the right direction for students to engage in learning that is meaningful to them. However, if their "choices" are similar to the current overarching educational system (such as sitting with a teacher to complete multiple choice worksheets in language arts, as seen in some schools that have less effectively been modeled after Sudbury Valley), then we end up in the same place as when we think technology is the answer without altering content and methodology.

Even so, an option such as Sudbury represents a radical rethinking of education. If the theory is applied well, with rich, creative learning experiences, it might be one example of an interesting and truly revolutionary approach. Of course, there are relatively few of these institutions, and an analysis of the longevity of their websites suggests a certain fragility. This is not surprising, given the fact that they are working against the current of educational thought and the move toward further standardization. Nevertheless, democratic schools, along with the more technologically-focused innovations of Khan Academy and Alt School, show that different models are possible. These efforts should be supported and applauded, along with the many, many alternative ideas that are being tested nationwide by those who are responding to the needs in their communities for new and better models to engage students in authentic, twenty-first century learning. Even if these alternatives reach only a small segment of the population, they are testing strategies and providing potential examples that could at some point help the majority of students. Just as Torrance and Sisk (1997) noted that the field of gifted education was housing creativity's best practices until mainstream educators realized their need for them, alternative models being put forth through the application of Design Thinking, the Maker Movement, Project Based Learning, 4.0 and Micro Schools, homeschooling, and other alternatives are valid in establishing new ideas that might stick now or in the future. The question we must address is whether any of these examples provide practical guidance to policy makers, administrators, and educators as to how the mainstream educational system could be changed to incorporate the creativity skills we seek.

The question of guidance for policy makers is very important because revolution, by its very nature, is a highly disruptive act. Students entering the school system 20 years from now would regard the change as an interesting historical fact, but for the students who are caught in the turmoil, the effects could last a lifetime. It is difficult for a large system to turn on a dime, but possible for individual schools, teachers, families, or entrepreneurs to step outside of a system that isn't working for them to create new options. For those that don't have the choice to sidestep the system, educators have a responsibility to invent the future while simultaneously delivering the highest quality education that they can today. As we explored with standardized testing, broad sweeping change on a centralized level is likely to create a disruptive wake for those whose needs aren't met by the new policies. It therefore benefits us to ask: Is it possible to fix the current system? Can we organize education in a way that helps children gain the domain expertise they require as they develop their creative and collaborative capabilities?

12.7 Can We Fix the Current Model?

The move to standardized education has been counterproductive for the development of creativity. The research shows this, the reports from individual teachers show this, and any theoretical analysis of initiative – given what we know about how to stimulate creativity – will also show this. And yet the move to standardization has important and worthwhile objectives. Providing a good standard of education for all children is a fundamental requirement of a modern educational system. If we accept that the move to standardization has valuable objectives, then ‘fixing’ the problem by simply rolling back to an earlier time would be unacceptable. Whatever solution we create needs to enhance educational standards for all children and build the creativity skills that are important for the twenty-first century.

But if a mainstream revolution seems to be either impossible or too disruptive to a deeply established system, what about an evolution? Revolution and evolution are often presented as polar opposites. But in reality they are both simply mechanisms for effecting change. Revolution, large or small, involves an abrupt change to the current regime. Evolution, however, involves the development of new structures through the retention of variations that are passed down through subsequent generations. The critical part of this process is that the variations that are retained are the ones that provide the best survival characteristics for the organism. We believe that it would be interesting to explore whether consciously using evolution as an analogy could help us move towards a better system without endangering the ‘inhabitants’ along the way.

12.7.1 What Would an Evolutionary Approach to Integrating Creativity into Education Look Like?

The relationship between evolution and creativity has been explored by a number of researchers, most notably Campbell (1960), who popularized the concept of Blind Variation and Selective Retention (BVSR), and Simonton (1998, 1999, 2011), who built upon Campbell’s work. Campbell (1960) identified three conditions that were necessary, under his model, for the creation of new ideas:

1. “A mechanism for introducing variation;
2. A consistent selection process; and
3. A mechanism for preserving and reproducing the selected variations” (p. 381).

The BVSR model attempts to explain creative thought at an individual level. But could it also provide useful insights at a systemic level? We think it might. Applying the evolutionary analogy to the educational sphere allows us to recast the move to standardized testing in a different light. By defining a specific set of tests and evaluating teachers via their students’ test results, the policy makers changed the landscape within the educational environment (selection criteria). Over time, educators changed their behaviors (created variations) and those who produced more successful variations stayed in the profession, while others left, or were asked to leave (selective retention). In essence, by focusing on test results, policy makers were attempting to direct the evolution of systemic behavior.

The concept of cultural evolution is controversial. We are going to sidestep this quite valid academic debate by focusing on a smaller scale. In this case, we are interested in how best practices within a learning environment could be developed and transmitted. In very simple terms, we are asking if evolution theory could help us understand how new ideas enter the teaching environment, get evaluated, and are retained or amplified. Furthermore, could we apply these principles to shape the development of future systems? In other words, could we direct the evolution of school systems towards more creative ends, and in doing so bring in change without causing excessive disruption?

12.7.2 Directed Evolution

The problem with evolution is that it can be very slow. Of course, slow is a relative term. Bacteria can reproduce at a rapid rate whereas mammals proceed in a more stately fashion. But the length of gestation periods is not the key limiting factor. A more important limitation is the whole idea of the generation of variation being 'blind.' In natural systems cells don't mutate with a specific aim in mind, they just mutate. It is only later that we discover whether the change was helpful, harmful, or neutral. In practical terms, this means evolution explores a myriad of cul-de-sacs before a really beneficial capability is developed. Evolution is therefore a very wasteful process.

Fortunately, applying evolutionary thinking within education doesn't require us to engage in completely blind variation. Decades of creativity research have produced a range of theories that seek to define the attributes of creative individuals, processes, products, and environments. When viewed through an evolutionary lens, these theories provide the basis for both sighted variations and the required fitness functions—sets of criteria that describe the desired characteristics of a solution. Applying a fitness function to any new idea would act like a sieve that allows us to retain those elements that score well on the function, and reject those that don't. It would help us define which attributes we should attempt to maximize, and which to minimize.

Of course, providing ourselves with sighted variation and applying the fitness function in a manner that allows us to a priori optimize each iteration moves us from the realm of evolution into directed evolution. However, before we can rush forward into our rapidly evolving educational utopia, we must first stop to consider whether our theories are really good enough to act as selective filters.

12.7.3 Are We Making Progress?

The process of directed evolution is often compared to trying to reach the highest point on a mountain range when all the peaks are covered in clouds: you can't spot the apex, but you can work out whether you are ascending. The risk is that you may spend a lot of time running to the top of various molehills, rather than up the adjacent mountain. One only knows the limits when further progress results in a descent.

In the context of creativity in education, we must ask what our measures of ascent would be. Given that creativity is usually regarded as a complex, multi-faceted phenomenon, the criteria are likely to reflect this. Let's start by sketching the broad requirements for a suitable fitness function.

It is fundamentally important that any such function should not exclude or de-emphasize the importance of domain expertise. Evidence from the teaching community suggests that creativity and the 3Rs (Reading, [W]Riting, and [A]Rithmetic) are often seen as mutually exclusive objectives (Beghetto, 2010).

Having asserted that our fitness function must honor the need for domain expertise, it is equally important to recognize that knowledge and skill are not enough. They must be supported by the appropriate creativity skills (Amabile, 1996). Therefore, developing creativity skills needs to be given equal weighting in the function. But what could go into this function?

12.8 A New Fitness Function

The new fitness function must comprise a set of criteria that is both intelligible and easy to measure. Without both of those conditions being met, it would be hard to convince the educational community that the fitness function was appropriate and valuable.

For the purposes of this paper, and to enable us to explore the practical applications of this concept, we are going to adopt the Torrance Creativity Skills (1979b). We selected Torrance because of the longevity, specificity, and broad appeal of his work:

1. Torrance (1979b) identified, defined, and developed this set of creativity skills based on the works of Guilford, de Bono, Parnes, and Synectics. The criteria have been applied throughout the decades, and the increasing body of literature on these skills (Catalana, in press; Cramond, 2013; Keller-Mathers, in press; Murdock and Keller-Mathers, 2002, 2008; Torrance, 1979a, b; Torrance and Safter, 1990, 1999) suggests that they appear to be as relevant today as they were when Torrance first proposed them,
2. Torrance (1979b) listed 18 specific skills that he identified in children demonstrating creative thinking. This specificity is important if we are to develop a fitness function that could actually be applied in a consistent manner.
3. These skills have been reliability tested over time through the Torrance Test of Creative Thinking (TTCT) (Cramond, Matthews-Morgan, Bandalos, and Zuo, 2005).

Before examining the Creativity Skills list in more detail, it is important to address a couple of points. First, the skills list only covers a subset of the dimensions one may wish to include when thinking about developing creativity skills. A broader model might incorporate criteria spanning all four areas within the 4Ps model outlined by Rhodes (1961): Person, Process, Product, and Press (or environment). Equally, it might be more appropriate to develop independent fitness functions for each of the four areas. Second, Torrance's list does not cover domain expertise, and therefore only represents a partial fitness function. However, we don't believe that this is a problem. The standardized testing movement has produced a wide range of domain-specific tests. Combining these with the Torrance skills shouldn't prove to be an insurmountable issue. In fact, the decades of application of Torrance's Incubation Model show that it has been used specifically to integrate the development of such creativity skills with content knowledge (Murdock and Keller-Mathers, 2002, 2008; Torrance, 1979a, b; Torrance and Safter, 1990, 1999). The very premise of the Incubation Model, to which these skills are directly related, is to achieve deeper engagement and more lasting content learning by asking students to think at higher, more creative levels of functioning (Torrance and Safter, 1990). Therefore, it would support the wide range of criteria already in place in the system that evaluates the development of domain expertise.

12.9 What Skills Did Torrance List?

Torrance (1979b) identified 18 skills that he believed were necessary for the development of the creative person. The skills were (Table 12.1).

Some of these skills can be appraised relatively easily. For instance, *produce and consider many alternatives* could easily be tested by counting the number of ideas generated by students. Others, such as *visualize it richly and colorfully*, would require a more subjective assessment. However, for each of the skills it is possible to develop specific metrics to determine whether an individual student or an entire class is climbing 'uphill' or 'downhill' as a result of any variation.

12.10 So, Where Is the Variation?

Up to this point, our discussion of evolutionary thinking has focused on the question of how one would evaluate new ideas for their abilities to develop creativity skills. But where would these new ideas come from? We see three possibilities: random variation, lateral meme transfer (the term used to describe an idea as if it were a gene), and deliberate variation.

1. Random variation, as its name suggests, describes things that happen by chance. Children might discover an interesting way of playing soccer that allows their teacher to hold a discussion of probability, and encourage the students to create new games. Or a student might mispronounce a word, which leads to a class discussion about neologisms and the challenge of inventing new languages. Random variations are unpredictable and could be thought of as being akin to the 'mistakes' that happen when a cell makes a copy of itself. Of course, many of

Table 12.1 Creativity skills

Skill	Definition
Produce and consider many alternatives	Fluency; generating many options.
Be flexible	Generating variety; different categories and perspectives.
Be original	Producing statistically infrequent responses; novel, unique perspectives.
Highlight the essence	Identifying the absolutely essential; focusing on what is important.
Elaborate – but not excessively	Developing details or ideas.
Keep open	Resisting premature closure.
Be aware of emotions	Recognizing emotional cues; understanding through feelings.
Put your ideas in context	Putting information into a larger framework.
Combine and synthesize	Putting new connections together.
Visualize it – richly and colorfully	Using vivid, colorful imagery.
Enjoy and use fantasy	Imagining, playing, and considering the nonexistent.
Make it swing! Make it ring!	Using your full range of senses.
Look at it another way	Seeing from a new or different perspective.
Visualize the inside	Describing the inside of things.
Break through – expand the boundaries	Changing the paradigm; going beyond given requirements.
Let humor flow and use it	Responding to incongruities and surprises using humor.
Get glimpses of the future	Imagining possibilities that do not yet exist.

Adapted from Torrance (1979b)

these variations will be uninteresting and will be quickly forgotten, but some will be retained because the teacher felt that they advanced her domain and creativity objectives.

2. Lateral or horizontal gene transfer describes the process by which two unrelated organisms transfer genetic information. On the face of it, this has no application to our area of interest. But, if we replace genes with memes, we can ask ourselves whether new ideas ever enter the world of education from completely unrelated areas. For instance, have Total Quality Management and Statistical Process Control had any influence on the idea of standardized education? Equally, the concept of 'slick presentations' as exemplified by computer tools such as PowerPoint® are now often found in student work. Websites such as Pinterest, which have attracted a large pool of teachers, offer particularly effective ways of transferring memes between geographically separate organizations.
3. Deliberate variation relates to the ideas that are consciously generated by administrators, teachers, parents, and students. In essence, deliberate variations are the results of asking, "How might we do this better/differently?" Within the mainstream system, that question would be focused on how one might develop

creativity skills in association with domain expertise. This is also where the revolutionary ideas, which we discussed earlier, fit into the overall evolutionary system. They are deliberate attempts to create new models.

These three sources of variations produce ideas that feed into the selective retention and reproduction of the overall evolutionary system.

12.11 Reproduction

Evolution requires reproduction. It is the means through which variation can be inherited, and therefore preserved. So, what is the analog of reproduction in our model? We see two main routes: explicit and tacit knowledge exchange. Both of these topics have been well explored by the knowledge management literature (Nonaka and Takeuchi, 1995). In summary, knowledge can be transmitted in two forms:

1. Explicitly encoding it into policies, books, teacher training courses, etc.; and
2. Demonstrating the knowledge in action that results in the development of tacit knowledge through observation and practice.

With this final piece, we have the basics of our evolutionary mechanism for changing educational systems. In summary, the model has three parts:

1. Administrators define a new fitness function that incorporates both domain expertise and creativity skills.
2. Variability in the system produces new outcomes.
3. Successful variations are retained and shared (reproduced), either as explicit or tacit knowledge.

12.11.1 What Does This Look Like in Practice?

We would like to take two recent examples and use our evolutionary lens to examine how they might help to build creativity in the classroom. Over the last three years, the first author of this paper has been working with Elmwood Franklin School, an independent Pre-K – 8th grade school. While this is a premier educational institution that highly values academics, the school's core values statement, which could be thought of as a meta fitness function, also includes "creative inquiry."

In the school's Reggio Emilia (Edwards, 1993) influenced kindergarten class, students are given an active role in choosing the areas they want to explore. Not bound to standardized testing, an inquiry about volcanoes could lead to a deep learning dive into lava, magma, and volcanic eruptions, without too much concern about staying on a specific script.

The first example involves a curious boy in kindergarten who began playing with a cup of water and markers. The boy realized that if he dipped the tip of the marker into the water, he created a "watercolor." Excited, he quickly reached for more cups, began to fill them with water, and started "testing" multiple colors together to see what they would form. As the rest of the students caught on, they also began creating "watercolors," which led to the whole group discovering which primary colors would create secondary colors. By the end of the afternoon, the room was buzzing with small children discovering various colors together.

From an evolutionary perspective, we would see this as an excellent example of random variation. The teacher set up the open space to explore, and the students made a discovery. The discovery itself was not predetermined, but the nurturing, exploratory environment allowed experimentation and insight to emerge organically. If she had been judging the variation by the fitness function, the teacher could certainly check off the creativity skills *produce and consider many alternatives, look at it another way*, and *visualize it richly and colorfully.*

When examined in isolation, the variation can be seen as moving the learning toward the direction favored by our new fitness function. But isolated changes are not going to produce a creative education system. The question we must ask is: Did the idea 'reproduce?' As far as we can tell, the answer is no. The teachers haven't recorded the activity in any way. It hasn't become part of any lesson plan, and a new teacher who joined the school last year wasn't made aware of the idea. In essence, the variation has died. This isn't necessarily a problem, because the teachers, students, and parents are exploring new ideas all the time. But if the school is interested in building up a stock of effective variations, it might be valuable to put more effort into capturing what works, so that it can be improved each year.

At the opposite end of the same school, you would find an example of deliberate variation. The eighth grade teachers developed a program called the Individually Determined Exploration Area, or IDEA project. This is a creative inquiry assignment that begins with each student generating at least 100 options exploring what he or she is curious about. Students learn various creative problem-solving techniques and converge on individual topics they want to learn more about. Over six months, students work across disciplines, plan, research, create, teach, and produce representational videos around their interests. If they used our fitness function, they would likely check off most of the skills Torrance (1979b) originally described. This project has been 'reproduced' for several years, and the design has been documented. This year, the concept has been expanded to include a wider range of teachers, and newly arrived teachers have also been involved in the project. One might even imagine that teachers leaving for other schools could transplant the ideas into their new environments.

12.12 Conclusion

Theories are only really of value if they enable action. While adopting an evolutionary perspective might be intellectually interesting, we have to confront the question, "What next?" We see four distinct steps in response to this question:

1. Evaluate both domain and creativity expertise;
2. Provide teachers with frameworks for teaching creatively;
3. View education from an ecosystem perspective; and
4. Co-ordinate the collection of effective strategies.

First, selective retention through fitness functions has already changed teachers' behaviors. The profession has become increasingly focused on achieving better test scores. This is an unsurprising result. The system will naturally move towards that which is being selected. Fortunately, this behavior pattern can be used to achieve a more creative educational system. In order to gain any ground whatsoever in making changes to the current system, we must first change the fitness function to include creativity skills within the assessment system. This does not need to be in the form of having a test with right or wrong answers. It could be done through a variety of assessment techniques such as the TTCT, portfolios, journals, projects, and putting the learning into context.

Second, if creativity is included within the fitness function, and domain expertise requirements are not relaxed in any way, then it will be essential to help faculty develop teaching strategies that incorporate both objectives. Mechanisms for teaching creatively, as well as teaching creativity, are available and have been well received. Design Thinking (Buchanan, 1992), Problem Based Learning (Hung, Jonassen, and Liu, 2008), and the Torrance Incubation Model (Torrance and Safter, 1990, 1999) are all excellent examples.

Third, so far, we have presented evolution as something that happens within the school environment, (i.e., teachers, administrators, and students interact and various ideas bubble up, are imported, or are deliberately created). But schools don't operate as isolated entities within a petri dish. Instead, they exist as part of an educational ecosystem (Haydon, 2015; Lichtman, 2014). The ecosystem contains the obvious players: teachers, administrators, students, parents, and products. Additionally, it includes the creative environment, teaching strategies, and outcomes. Each of these elements could be a source of variation, selection, and reproduction. Therefore, school systems must pay conscious attention to the overarching environment in order to take advantage of all the variation that is being constantly created.

Finally, researchers have been in a great debate as to what works and what doesn't. This has stopped us from making any significant progress. Borrowing from the world of medical research, systematic literature reviews in the style of the Cochrane Collaboration, an international effort to collect and coordinate the highest quality medical research projects, could help to narrow the search space by identifying the best 'base camps' from which to start exploring. We need a central hub to work collectively and quickly run prototypes of the ideal learning conditions for creativity skills and domain expertise.

School doesn't have to be a battle between competing objectives. Revolutions, quiet or otherwise, are not the only answer. Instead we can encourage the system to evolve in the direction of greater creativity by defining a fitness function that selects for the attributes we desire. Granted, we also need to stimulate and capture interesting variations, but that isn't a problem because teachers, students, parents and administrators are coming up with new ideas all the time.

Let's work together to evolve an education system fit for the twenty-first century.

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Chapter 13
Promoting Abduction – A Teaching Experiment on Creative Learning Processes in a High School Classroom Context

Lene Tanggaard and Rasmus Hjorth

Abstract This paper draws on a recent study of teaching experiments in a Danish gymnasium (upper secondary school) context. The aim of the study was to afford students time to devise creative solutions to specific problems in each subject area. For the purposes of the study, abductive reasoning, applied to ordinary subjects in the classroom in a high school context, was seen as a driver of creativity. This rather conservative approach to teaching creativity at secondary school level can be contrasted with more radical, reform-oriented traditions within the field of creative education. The paper discusses the advantages of the conservative teaching approach in relation to promoting students' creativity in an upper secondary school context.

13.1 Introduction: New Demands – New Educational Contexts

The debate on education policy has for decades been based on the premise that complexity has increased in the late modern period (Hobel, 2012). It has been put forward that choices are no longer as simple and that the individual therefore has to be able to handle increasing amounts of information, opportunities, risks, etc. Sociologists have described late modern society using terms such as uncertainty, risk (Beck, 1992), reflexivity, workability, individualisation (Ziehe, 1989), globalisation, loss of tradition, and multiplicity of choices (Giddens, 1991). The debate on schools and education has taken this to mean that we can no longer simply develop pupils' convergent thinking but must also develop their skills with respect to handling new opportunities and challenges. The need for new skills has been understood in two ways. Firstly, such skills are linked to *personal* development and

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maturity, and secondly to the individual's future in a changing workplace environment (Hermann, 2003; Telhaug, 1994).

It was within this context that work on the reform of the Danish gymnasium was initiated in the late 1990s, leading in 2005 to, among other things, the decision to include the teaching of creative and innovative skills as educational goals in the preamble. One reason for the decision was the belief that the twenty-first century presents a different set of challenges and new circumstances for those entering the job market. The traditional career path, whereby the employee would gradually climb a 'ladder' towards a more senior position in a large organization, is a thing of the past (Keogh & Galloway, 2006; Matlay, 2011). Today many new jobs are created by small organizations and start-ups, who expect their employees to be adaptable, flexible and to form self-directed relational working teams (Duval-Couetil, 2013; Ouimet & Zarutskie, 2014). Rapid changes in the business world have emphasised the need for the individual to be able to continually learn, adapt, interact and create their own new opportunities. Education should therefore facilitate the acquisition of these abilities (Zhou & Hoever, 2014).

This paper has grown from a PhD project, which attempted to develop and explore the possibilities of an educational approach that reinforces *creative* skills in pupils through day-to-day teaching in the upper secondary school system. Building on this study, this chapter will try to answer a series of related questions. These are primarily questions such as: How should we define creativity in the context of the upper secondary school? Is it possible to identify characteristics of educational and teaching principles, covering all subjects and contexts, that could reinforce creative skills without compromising educational content?

13.2 Creativity in a Danish High School Context

Although much has been said and written about creativity in schools and in education generally, several questions have not been answered fully. There are three reasons for this, which are particularly evident in the case of Danish schools. *First*, current research and development efforts focus on strengthening creative skills through teaching principles and methods that do not pay particular attention to the specific context, for instance, the subject or discipline being taught (see Jensen & Kromann-Andersen, 2009). *Second*, existing research and current development work seldom take place in a typical institutional framework in a gymnasium (with respect to the individual subject or lesson) but are more likely to work within an exceptional framework – such as cross-discipline project weeks, 24-h camps etc., so that the above questions are not even on the agenda (see Hansen & Byrge, 2010). *Third*, existing research and current development work typically treat creativity in a mercantile sense, as a means to developing new (marketable) products, rather than seeing creativity in relation to the subject and as a function of understanding subject-related aspects, topics, etc. Existing research and development efforts often carry a hidden agenda, with ambitions to *radicalise* significant aspects of the education system's goals and framework, or at least to *modify* them.

An example of the former ambition – *radical reform* – can be found in the conclusions of the respected British think tank, Demos (Seltzer & Bentley, 1999), according to which there is an urgent need for radical change in education in the West – from primary school to university – if we are to equip children and young people for the creative society of the future. Demos strongly criticises the way in which the education system in Western countries is organized – with class teaching, exams and the teacher's monopoly on teaching, etc. It outlines a new pedagogical model for the creative school of the future, in which the fixed curriculum is cut in half and pupils learn through projects that are developed in close cooperation with companies, organizations and local contacts.

The research project on which this chapter is based does not entertain such ambitions for radical change, for reasons which will be explained in the next section.

13.3 General Challenges in the Danish Context

The preamble listing goals for the four types of secondary education states that courses must "*develop the creative and innovative ability of pupils*" (Danish Act on Danish Act on Secondary Education, 2010:Article 2, Clause 4). The preamble does not contain more detailed instructions on the interpretation of creativity (or innovation) in secondary schools, nor does it mention which educational principles may be applied in order to strengthen pupils' creative skills. The *teaching plans* for individual subjects also fail to elucidate how these terms should be understood and/or applied. Nor are there conventions or guidelines to help teachers assess pupils' creative skills through various examinations in the gymnasium. This means that, to a significant extent, it is up to teachers and school directors to decide what creativity means and how one should approach teaching with a view to nurturing creative skills on a day-to-day basis. The fact that the requirement has been laid down in such a fashion means that practitioners have to apply themselves to interpretation; this can make the transition from statutory requirement to practical implementation somewhat difficult. A small survey we conducted as part of the PhD course, in connection with a seminar on creativity for teachers at Skive Gymnasium in Denmark (N = 70), showed that upper secondary school teachers tend to define creativity in very different ways. The 70 teachers at Skive Gymnasium were first asked which of the following four definitions best matched their understanding of creativity. They were also allowed to formulate their own definition. The figure in brackets is the number of teachers who agreed with the definition.

1. An idea is creative if you thought it up/created it on your own. It is immaterial whether others have had the same idea (N=20).
2. An idea is creative only if you have thought it up yourself *and* it diverges from the solution to the same challenge typically offered by other people (N = 21).

3. An idea is creative only if it diverges from other people's solutions and is useful/applicable. An idea cannot be creative if it cannot be put into practice (N = 19).
4. An idea is creative only if it is completely new (that is, if no one has thought of it before) and works so well that it creates or changes an area/domain (such as a subject or branch), such that new possibilities open up (N = 4).[1]

The same study also showed that many teachers are uncertain how to deliver teaching that promotes creative skills. Moreover, 45 % of teachers said that their need of more knowledge on the subject was "very significant" or "extremely significant". Only 11 % answered that their need was "slight" or that they had "no need". The remaining 44 % were "somewhat" in need of more knowledge.

According to Kampylis, Berki, and Saariluoma (2009), such a lack of knowledge and understanding can reduce the teacher's interest and motivation with respect to prioritising the matter. By means of a survey of 132 Greek teachers Kampylis found that, with respect to creativity, "*Only one in five participants (22.3 %) feels well-trained to facilitate students" creativity*" (p. 26), and concludes that, "*lack of understanding creates a lack of teachers' motivation for working towards the realization of creativity at school"* (p. 19). This may help to explain why only 43 % of the teachers at Skive Gymnasium participating in the survey felt "strongly" (26 %) or "very strongly" (17 %) *obliged* to foster the creative skills of their pupils. Also, this could point to the fact that it is hard to feel responsible for teaching something if one does not feel suitably equipped – even if the requirement has been made law.

A series of researchers (Beghetto, 2006; Fasko, 2001; Runco, 2003; Westby & Dawson, 1995) furthermore suggest the existence of an interesting dichotomy. Many teachers express a positive attitude towards creativity; research results on the other hand suggest that teachers in general do not value those personality traits that are linked with pupils' creativity (e.g. risk-taking, impulsiveness and independence). Thus, many teachers have a negative attitude towards, and low tolerance for, the behaviours and markers that are associated with creativity, even though they generally say that they appreciate creativity. One reason for this disconnect may be that it is the task of teachers to maintain *order and discipline* in the classroom (Westby & Dawson, 1995). Another reason may be that there is *uncertainty* and a considerable amount of *preparation* in connection with the activities (Aljughaiman & Mowrer-Reynolds, 2005). According to Alencar (2002:15) a result of these concerns is that many teachers adopt "restrictive practices" with respect to the realisation of pupils' creative potential, which is characterised by:

> (1) considerable emphasis on pupils providing the right answer, (2) an exaggerated focus on the reproduction of knowledge, (3) low expectations with respect to pupils' creative potential, (4) emphasis on students' compliance and passivity and (5) low priority given to pupils' use of imagination, etc.

Numerous international studies document the consequences of these five issues, citing a mismatch between creativity objectives in national curricula and actual

[1] Six teachers formulated definitions that cannot be directly matched with one of the four definitions.

outcomes (e.g. Diakidoy & Kanari, 1999; Dinca, 1999; Kampylis, 2008; Kowalski, 1997; Saarilahti, Cramond, & Sieppi, 1999).

In our study of creativity-fostering teaching in the gymnasium, we define **creativity as *the formulation of a solution that is abductive and meaningful from the individual's point of view* .** Being "meaningful" in this context is understood as something that may possibly prove to be of value, while "abduction" is understood as all types of processes where people make a qualitative leap from the incomplete data available to them, and through an element of qualified guesswork express something they have not previously created.

Such a definition allows that it is sufficient for the pupils who think them up for solutions (products) simply to be new and meaningful in relation to previous ideas they might have had. Assuming this definition, all thinking – as Dewey (1916) formulates – is *"native [and] original, with him who carries it on, even if everybody else in the world already is sure of what he is still looking for*" (p. 148). There is no requirement here that the solution be *new* compared to all others, or that it has *value*, that is, that it function as a practical solution to a specific challenge. It is enough that the individual simply incorporates creative (abductive) elements as part of his or her solution and that, at the same time, the solution appears meaningful to pursue because it represents something that may possibly have, or may later acquire, value (in the eyes of the individual creating the solution). In this understanding, creativity is a multi-faceted term covering, for example, everything from a child's spontaneous drawings to Einstein's scientific theories.

The above understanding of the concept of abduction – as reflective guesswork in all areas of life – differs from the term's original meaning for the philosopher C. Peirce (1839–1914). Peirce uses the term in a scientific-philosophical discussion of epistemological forms of working and inference, and thus does not deal explicitly with the concept of creativity. Peirce defines abduction as: "looking for a pattern in a given phenomenon and propose a hypothesis on this basis" (Peirce, 1998, vol. 2, p. 299). Or as formulated elsewhere: "… to examine a large number of facts and to allow these facts to propose a theory" (Peirce 1958: 209). The Greek philosopher Aristotle (384–322 BC) described similar ideas with the form of deduction *apagoge* – an argument that is not necessary but may be likely or possible. If the concept is relevant in this context, it is because Peirce's concept of abduction describes the thought processes which – unlike inductive and deductive forms of inference – deal with creating new ideas, hypotheses, concepts, etc., in situations where we have to try things out and make an educated guess without first having all the data (including methods) that are necessary to create reliable answers/solutions. Abduction thus seems to be present in situations where something creative is happening.[2]

[2] In an attempt to widen the concept of abduction from its narrow epistemological focus on hypothesis formation and knowledge production to also accommodate more classic creative processes such as artistic production, we can perceive abduction as "all types of processes in which we create a qualitative leap from the incomplete data we have available, and through an element of qualified guesswork express something that we have not previously created." Inspiration for such a broader

In this chapter, it is a fundamental assumption that creative products share these common characteristics (abductivity and meaningfulness) within the domain of their origin, whether we are talking about art, football, business, education science, etc. Even if creative products take different forms within different domains and may look different on the surface, they nonetheless share these fundamental characteristics. This approach follows Kupferberg et al. (2009), who maintains that we can differentiate between various creativity regimes (domains) with the same basic definition of creativity but varying ideas as to when an idea can be said to be creative, depending on the challenges and goals of the domain. Thus, various creativity regimes share the same definition – there is only one correct definition of creativity according to Kupferberg – but express it differently in the different domains.

13.4 The Empirical Approach

The aim of empirical work in this context has been to develop and examine teaching that can elucidate opportunities for strengthening pupils' creative skills, based on specific training and educational principles and input from all subjects within the traditional institutional framework of the gymnasium**.** A *primary* goal of the investigation is to find out to what degree one can identify special characteristics within teaching and educational principles across learning contexts (e.g. relating to subject, year, level, etc.) that can strengthen creative skills without compromising on academic goals. A *secondary* goal is to examine to what extent there are learning contexts where it is particularly difficult to ensure the aforementioned learning goals or where teaching may benefit from diverging from the general recommendations for creativity-fostering methods in an effort to attain the aforementioned learning goals.

The investigation will be based on so-called Educational Design Research (EDR). EDR is a relatively new set of research methodologies that are characterised by two things. *The first* is that educational researchers work with practitioners to design and implement education products which are tested, examined and improved on an ongoing basis in natural and complex teaching contexts in a way that addresses and *resolves real problems* found in practice. *The second* – with a basis in the first activity – involves education researchers developing research-based *theoretical concepts* that go beyond the specific findings of the context in which they were refined. EDR may thus be defined as a genre in which the development of iterative

understanding of abduction processes can be seen, for instance, in Johnson-Laird (2006), who describes abduction as an exercise in imagination, that is, using the capacity for imagination and fantasy – including playing with our existing knowledge. In the same style, Bateson (1984) proposes that abduction appears in metaphors, dreams, parables, allegories etc. Fredens (2009) draws a more classical parallel to the concept of creativity given in Guilford (1967) and perceives abduction as holistic/lateral thinking, that is,'out-the-box-thinking' that cuts across multiple trains of thought and therefore can break through the known framework and challenge conventional thinking.

solutions to practical, complex education problems also constitutes the framework for an empirical investigation that can lead to the formulation of theoretical concepts. In EDR, the classic distinction between research and development does not apply.

The aim of EDR is to *understand* a given phenomenon (research) and to help to *change* (develop) the phenomenon, e.g. a particular learning environment. In traditional action research (e.g. Mathiesen, 1973), gathering information and developing a theory are primarily means to improving/serving the action (i.e. resolving the practical problem). The information gathered by the researcher during the action is first applied *to the action* in an attempt to improve and refine it; it is not applied in the general development of theory. Action research may be described as follows: the action researcher is a devotee of the action, not the theory. In other words, the action is weighted more heavily and determines direction. In EDR, the opposite is the case. Here the development of didactic theory is the overall, or at the very least a subordinate, goal (Mckenney & Reeves, 2012). Furthermore, in EDR it is typically the researcher who takes the initiative in both the design process and the research process and who, together with the practitioners, identifies problems and (in collaboration) develops proposals for ways to improve practice. In action research, the role of the researcher is typically less far-reaching and in certain situations is limited to simply managing the research project (Wang & Hannafin, 2005). If one prefers the label ‘action research’ to EDR research, one can perhaps qualify it in relation to action research by saying that (a) the object of the exercise is always *education*, (b) the *development of theory* is at least as important as finding a solution to a practical problem and (c) the researcher has a far-reaching *role* throughout the project.

The study has been made possible through a grant from Central Denmark Region in connection with the formation of a pool of funds for youth education on the theme of “innovation and entrepreneurship” (2011). Support has also been given by Aalborg University and the gymnasium, in the form of lesson hours. The grant and application together set various guidelines for the study, which for example include *start date* (middle of 2011), *duration* (3 years),[3] *target group* (upper secondary education in Central Denmark Region), *research context* (a single, or several upper secondary education centres in Central Denmark Region), *research focus* (a topic of interest spanning subjects and institutions) and *scope* (stakeholders in Central Denmark Region). The project *practitioners*, chosen by school management, were seven teachers in 13 subjects, who each received *financial compensation* of 100 h for participating in the project. The management of the gymnasium furthermore stipulated that a condition for cooperation was that each pupil had to fill in the survey no more than twice (each time taking 20 min). This was in consideration of minimising any disturbance to pupils caused by the project.

The management of the gymnasium were instrumental in preparing the project application and subsequently appointed seven teachers, taking into account their knowledge of each individual teacher’s interests, commitment, combination of sub-

[3] Since then, the project term was extended (in early 2013) to four years and the PhD staff employed on reduced hours.

Table 13.1 Overview of 27 prototypes

No	Subject	Teacher	Date
1	Social studies – terrorism	Kira	10.04.12
2	Social studies – planning/market economics	Mads P.	11.04.12
3	Social studies – globalisation/international economics	Anders	11.04.12
4	Social studies – India	Kira	24.04.12
5	Danish – Hamlet	PW	25.04.12
6	Biology – methods in genetics	Lone	25.04.12
7	Danish – Sommerfugledalen (poetry)	Ditte	27.04.12
8	Social studies – politics ('øde-ø' – the desert island)'	Anders	01.05.12
9	German – oral exercises	Bodil	02.05.12
10	English – prepositions	PW	21.05.12
11	English – prepositions(version 2)	PW	01.06.12
12	German – film analysis (control lesson)	Bodil	18.01.13
13	Social studies – the EU	Mads P.	22.01.13
14	Religion – Buddhism (text analysis)	Kira	23.01.13
15	German – film analysis and speech writing	Bodil	25.01.13
16	Biology – DNA (control lesson)	Lone	28.01.13
17	Social Studies – EU/the Council of Ministers (control lesson)	Mads P.	30.01.13
18	Social studies – politics/sociology, 95 % objective	Anders	07.02.13
19	Biology – DNA	Lone	18.02.13
20	Art – analytical strategies	Ditte	22.02.13
21	Chemistry (control lesson)	Lone	28.02.13
22	English – blogging and India	PW	12.03.13
23	English (control lesson)	PW	18.04.13
24	Chemistry – methods for identifying liquids	Lone	07.03.13
25	Danish – Impressionism (control lesson)	PW	08.10.13
26	Danish – Impressionism (text production)	PW	08.10.13
27	Biology – protein synthesis and genetic engineering	LM	03.04.14

jects and cooperation skills, etc. Table 13.1 shows the 27 classes, of which 21 are experimental lessons and six are control lessons.

As Table 13.1 shows, the 27 lessons are taken by seven secondary school teachers in 10 different subjects.

The study endeavoured to carry out its work:

- in ordinary school classes (at Viborg Gymnasium and in connection with the Higher Preparatory Course)
- within the timetable hours
- in a typical single-subject class (90 mins)
- in a subject scheduled for that particular point in time
- with the class's usual subject teacher.

13.5 Method

The study involved seven gymnasium teachers and featured 21 experimental classes. The project was introduced by way of three workshops with a focus on the challenges related to fostering pupils' creativity and possible ways of doing this. These were followed by workshops with a focus on the interim results/test results of the project and findings, with a view to refining subsequent educational product design and experimental procedures. In the *first workshop*, the researchers' initial *identification of problems and explanations for their causes* were discussed with the seven practitioners. This included a general solution based on strengthening creative skills and subject-related objectives simultaneously, within the institutional framework. The *second workshop* dealt with general *design stipulations* by way of an introduction, whereby researchers and participants pooled their thoughts. There was in particular a discussion of the definition of creativity in the context of the gymnasium, of possible task types that could set creative processes in motion and of general structures that could facilitate creative processes. In the *third workshop*, a template was agreed for *an ideal method of cooperation* between researcher and teacher with respect to developing specific measures.

We identified nine chosen design stipulations, whose aim was to place pupils under *pressure* to create. This would necessitate creative *processes*, whereby creative *skills* would be developed. The design stipulations were: (1) problem solving, (2) realistic tasks, (3) encrypted data, (4) distinct work procedures and deferred assessment, (5) individual idea generation and 'brainwriting', (6) clear and significant productivity demands, (7) structured analysis, (8) cooperation and (9) feedback.

The nine design stipulations were assembled in a version of the creative process model (Mumford, Medeiros, & Partlow, 2012) specially adapted for teaching and detailed in three main phases in which pupils: (a) are given a *task* to solve (abductive opening), (b) propose solutions through *idea generation* (abductive searching) and (c) take part in *technical debriefing* with an analysis, assessment and clarification of technical errors and deficiencies (abductive transfer). Each main phase is linked with three of the nine design stipulations. Other researchers will be unlikely to have assembled exactly this model or set of design stipulations. There must necessarily be an element of choice and interpretation when selecting fundamental design requirements based on the literature.

Table 13.2 combines the overall abduction-didactic model – including the three stages – with the design assumptions identified in the existing literature.

When teachers are to construct their own trial activities in accordance with the above model, the three stages are considered to be ones that <u>must</u> be followed (MUST assumptions), while the content of the 9 design assumptions is considered to be something that <u>can</u> be followed (CAN assumptions). Teachers in the project have composed the study's trial lessons and control lessons with very different tasks, processes, deadlines, etc. A typical lesson design is illustrated in Table 13.8. The academic questions in the task are themselves the basic element that determines to what

Table 13.2 The coupling between the didactic model and design assumptions

Model phase (BE)	Design assumptions (KAN)
Phase 1: abductive opening	Compared to Phase 1, this basically involves principles that can guide teachers in creating tasks which:
=Pupils receive an *assignment* they must solve which requires abduction	(1) focus on problem solving
	(2) are realistic
	(3) are formulated in areas where pupils have a degree of knowledge (encoded data)
Phase 2: Adductive search	In comparison, phase 2 basically concerns principles that can guide teachers in the use of:
=Pupils create answers/proposals using *idea generation (abduction).*	(4) separate work processes
	(5) individual idea generation and brainwriting
	(6) clear and high-level production requirements
Phase 3: Abductive transfer	In comparison with Phase 3, this basically concerns principles that can guide teachers in:
=The pupils participate in *technical debriefing*, which makes clear the technical faults/omissions (e.g. via analysis and assessment).	(7) structuring the pupil's analysis
	(8) establishing cooperation in the analysis phase
	(9) providing feedback for pupils

extent abductive processes are involved. The questions should also guide the choice of specific processes, tools, etc. The project has identified 10 basic types of abductive questions (in the thesis these are called "abductive openers") where pupils can work on creating more or less good solutions. For example, assignments that require pupils to develop ideas for explanations, interpretations, analogies, definitions, simplifications, stories, visualizations/formulations, problem solutions, study design and bodily movements. All these types of questions can be designed so that pupils do not know the solutions in advance and cannot find them via formulas, recipes or specific procedures – and thus must make their own abductions (proposals). In fact the only requirement is that pupils work on creating solutions with quality, and that the quality of the solutions can subsequently be made clear to a greater or lesser extent. Appendix elaborates the 10 identified forms of abduction and provides examples.

13.5.1 Observation of Classes

Each of the lessons was observed by the PhD student. Observation of lessons was *not* intended to result in specific statements about the degree of learning, skills development etc. that took place during the lesson for each pupil, or to derive from that anything about the quality of the design stipulations.

13.5.2 The Pupil Questionnaire

All pupils taking part in an experimental class filled out a *questionnaire* at the end of the class. One role of the questionnaire was to capture the individual's experience of the experimental lesson.

13.5.3 Focus Group Interview with Teachers

Towards the end of the project, as results began to emerge, it was furthermore decided to conduct a semi-structured, group interview with a focus group of seven teachers, which would last 3 h and deal with issues of quality. The purpose of the focus group interview was, among other things, to recreate group processes, to activate forgotten details and to formulate a basis for comparison. This would in theory enable participants to express themselves explicitly on aspects of their experience that they may not have consciously noted, or to add details to the statements of others where they sympathised with these (Crabtree, Yanoshik, Miller, & O'Connor, 1993, Krueger, 1998, Kvale & Brinkman, 2011, Merton, Fiske, & Kendall, 1990).

13.6 Results

Findings from the project experiment, with the three phases and nine design stipulations, have led to several main conclusions.

First the study shows that the experimental lessons were, in general, significantly better at fostering pupils' creative skills than the control lessons and that there seems to be no difference in the degree of academic learning in the situations chosen by teachers (see Table 13.3). This suggests that there is an opportunity for introducing creativity to a variety of academic areas and task types in gymnasiums and therefore developing broad-spectrum creative skills.

This is especially positive, because creative skills consist of various elements in various situations and are determined by the type of task (DeSeCo, 2002) – and because there is a greater transfer from the learning context to the application context, the more varied the learning context are (Yamnill & McLean, 2001). Added to this, teaching creative skills is not just a matter of developing certain cognitive structures, practical skills, etc., but also about providing experience (work habits) of various applications. It is therefore crucial that creative skills are not taught through standard exercises that are detached from real application scenarios (such as 'find potential applications for a sock') but that they can be imparted through a wide range of contexts specific to the discipline.

Second, the study highlighted several interesting *relations* between abductivity, motivation and academic content. For example, it was found that pupils' motivation fell more sharply in control lessons ($r = -0.34$) than in experimental lessons (-0.07) in a subject that was felt to be difficult (see Table 13.4). In other words, pupils seem to

Table 13.3 Differences in creativity sub-objectives and overall objectives between control and experimental lessons

	N	Control lessons	N	Experimental lessons	Difference (Δ)	P-value
Academic level	128	0.13 (0.01;0.25)	362	0.05 (–0.03;0.14)	–0.08 (–0.25;0.08)	0.34
Motivation	129	0.13 (–0.02;0.27)	366	0.78 (0.69;0.87)	0.66 (0.48;0.83)	<0.001
Abductivity	129	–0.34 (–0.55;–0.14)	436	0.74 (0.66;0.83)	1.07 (0.90;1.28)	<0.001
Creativity	128	–0.10 (–0.43;0.22)	357	1.55 (1.36;1.74)	1.65 (1.28;2.02)	<0.001

Pupils were asked to give a score reflecting what they felt about academic content, motivation and abductivity in the specific lessons, based on a 5-point scale ("very high" (+2), "high" (+1), "some" (0), "low" (−1), "none" (−2))
The figures are calculated on an average of 95 % CI and were adjusted for background variables (such as gender, age, year, subject and level)
The degree of creativity was found by adding the pupil's answers to the three aspects of academic content, motivation and abductivity
Example: In the experimental lessons, pupils gave a score of +0.74 for the experience of using their imagination (abductivity): this corresponds most closely with "high". The same result for the control lessons was –0.34. This represents 15 pupils in an experimental lesson (involving 20 pupils) answering "high" and five pupils answering "some"; and seven pupils in a control lesson (involving 20 pupils) answering "low" and 13 "some"

Table 13.4 Correlation between creativity sub-objectives in experimental and control lessons

	Abductivity		Resistance		Academic level	
	Control	Experim.	Control	Experim.	Control	Experim.
Motivation	r=0.16**	r=0.18*	r=–0.34**	r=–0.07	r=0.43**	r=0.25*
Academic level	r=0.07	r=0.14	r=–0.16*	r=0.07		
Resistance	r=–0.04	r=–0.04				

The correlation coefficient (r) shows the relation between the creativity sub-objectives. The number (r) is always between −1 and 1. If the number is positive, one indicator rises when the other rises. If the number is negative, one indicator falls when the other falls. If, for example, the number is 0.50, this means that one variable explains 25 % (0.50 * 0.50) of the variation in the other
The numbers in bold are correlations in experimental lessons. Other numbers are correlations in control lessons
* P<0.05 ** P<0.001

have better staying power in an experimental lesson than in a control lesson. Furthermore, resistance seems to reduce academic learning in control lessons (r=–0.16*), but not in the experimental lessons (r=0.07). Finally, it seems that pupils' motivation rises with greater demands on them to provide new (imaginative) answers.

Third, the study shows the significance of various background variables. For example, it appears that the superordinate *discipline* (humanities, social science, natural science) seems to be influential. Pupils record greater motivation and academic content in the humanities compared with the social and natural sciences (see Table 13.5).

Table 13.5 Significance of academic subject for creativity sub-objectives and overall objectives

	Motivation		Abductivity		Academic level		Overall	
	Experim.	Control	Experim.	Control	Experim.	Control	Experim.	Control
Humanities	Reference	Reference	Reference	Reference[a]	Reference[a]	Reference	Reference	Reference
Natural sciences	–0.29*	–0.11	–0.09	–1.49[b]	–0.19[ab]	0.01	–0.45	–1.56
Social science	–0.05	0.02	–0.15	–1.69[b]	–0.22*[b]	0.12	–0.48	1.53

In experimental lessons, "N" must not exceed = 436. In control lessons, "N" must not exceed = 129
Letters in a series (a, b, c) indicate a significant difference between various reference points
Asterisks (* or **) indicate significance in a single value, where no reference point was sought (* $P<0.05$ and ** $P<0.001$)

Table 13.6 Comparison of creativity indicators in various types of lesson

	Control (12, 16, 17, 21, 23, 25)		Imaginary (1, 3, 4, 24)		Real (2, 5, 6, 8, 9, 13, 15, 22, 26)		Classroom (7, 10, 11, 14, 19, 20)	
	N	Average (95%CI)	N	Average (95%CI)	N	Average (95%CI)	N	Average (95%CI)
Academic level	128	Reference[a]	151	–0.08 (–0.27;0.11)	60	–0.34 (–0.59;–0.09)[b]	138	0.01 (–0.18;0.21)
Motivation	129	Reference[a]	151	0.88 (0.68;1.08)[b]	60	0.40 (0.14;0.66)[c]	142	0.49 (0.29;0.69)[c]
Abductivity	129	Reference[a]	183	1.27 (1.06;1.49)[b]	95	0.88 (0.62;1.13)[c]	145	0.97 (0.74;1.20)[c]
Creativity	103	Reference[a]	86	2.11 (1.66;2.72)[b]	49	0.89 (0.44;1.70)[c]	53	1.32 (0.95;2.17)[bc]

Letters in a series (a, b, c) indicate a significant difference

This suggests that teachers of the social and natural sciences should be particularly attentive to the need to give pupils sufficient information and ensure thorough feedback. The difference in motivation and academic content is however less marked in experimental lessons than in control lessons. The experimental lessons were, it would seem, good at limiting the difference in the need for abductivity between subjects and thus could neutralise what one might call the 'monopoly' of humanities on creativity.

13.6.1 Main Findings from Phase 1 (Abductive Opening)

Under *Phase 1* in the model for abductive learning, the lesson should provide a *task* that pupils can try to solve using abductive reasoning. In other words, pupils should be given a task for which they do not know the solution, or cannot derive an answer using familiar methods. Instead they must offer ideas based on their existing knowledge. There are three design stipulations with a special connection to Phase 1. These are stipulations that can guide teachers in creating tasks, taking into account: (1) problem solving, (2) realism and (3) encrypted data. Findings from the study's experiments in Phase 1 suggest several main conclusions with respect to the design of problem-based and realistic tasks.

First it seems that learning outcomes are slightly *reduced* if the pupil is asked to give interpretations, explanations, recommendations, etc. on a more general *understanding-related* problem ("in the outside world"). Such a problem might for instance require proposals for solving general problems related to terrorism or the interpretation of fundamental elements of Buddhism (see Table 13.6). Perhaps the reason for reduced learning outcomes is that technical learning elements may be abstract and difficult to relate to and pupils may feel that they lack the knowledge for solving real-life, complex problems.

Second, it seems that learning outcomes are relatively *reinforced*, together with motivation and abductivity, when tasks relate to *specific* examples that pupils can relate to and which they are asked to *imagine* themselves being in, as well as actually solving a particular challenge that requires various forms of personal involvement (e.g. being shipwrecked on a desert island, a member of a flying squad, or a writer in Shakespeare's workshop, etc.) (see Table 13.6). Pupils appear to see these types of task as clearer, more relevant and more interesting. This would suggest that problem-based and realistic tasks could benefit from the inclusion of certain imaginary elements (e.g. working with hypothetical, rather than real, climate-change problems).

Third, it is important that creative skills are taught in areas where pupils have a *degree of knowledge*, since new ideas are created on the basis of our existing knowledge. Pupils' knowledge should be neither *over-codified* – in that they have so much knowledge that solutions more or less suggest themselves – nor *uncodified*, in that they possess insufficient knowledge on which to build their solutions. Pupils' knowledge should preferably be *encrypted*, so that they have enough knowledge to understand the problem inherent in the task, have some idea of which solutions would not work and can infer the directions in which sensible solutions might be found, without having so much insight that the answer is self-evident. This is confirmed by the detailed answers pupils gave in experimental lessons (13, 24, 19, 15), which are least positive in terms of effect. These evaluations are typically given when pupils either have *too much* knowledge and thus feel that the lesson is pure revision and does not result in learning new facts or in creative challenges (which seems to be the case for lessons 13 and 15); or *too little* knowledge and thus feel that the creative challenges of the lesson are too difficult and represent a barrier to academic learning (which seems to apply to lessons 19 and 24).

13.6.2 Main Findings in Phase 2 (Abductive Searching)

According to *Phase 2* of the model for abductive learning, teaching should involve search processes whereby pupils apply abductive procedures in an attempt to create their proposed solutions to the relevant task. There are three research-supported design stipulations with a special connection to Phase 2 of the model. These are stipulations focusing on: (4) distinct work procedures and deferred assessment, (5) individual idea generation and 'brainwriting' and (6) clear and significant productivity demands. Findings from the study's experiments in Phase 2 suggest several main conclusions with respect to the design of distinct work procedures, individual idea generation and brainwriting.

First, in only 14 of the 21 experimental lessons was it possible to ensure a clear distinction between idea generation and work procedures with evaluation (see Table 13.7). In the remaining seven experimental lessons, pupils were told – either alone or in groups – to alternate between idea generation, analysis, evaluation, etc. in creating *a single* finished answer.

Table 13.7 Work procedures in the 21 experimental lessons

	1	2	3	4	5	6	7	8	9	10	11	13	14	15	18	19	20	22	24	26	27
Plenum/teacher presentation					x	x		x		x	x					x	x	x	x		
Preparatory pupil work					x	x		x	x	x	x					x					x
Idea generation (individual)	x	x	x	x		x	x	x				x	x		x	x	x	x	x		
Idea generation (pairs/groups)																					
Categorisation		x										x			x						
Discard identical ideas							x						x								
Assess/choose ideas (alone)				x																	
Assess/choose ideas (in pairs)	x																	x			
Assess/choose ideas (in groups)	x	x	x	x			x					x			x	x			x		
Build on answers			x	x		x		x				x	x						x		
Produce a single answer			x		x		x			x	x		x	x			x	x	x	x	x
Critique of answer														x							
Presentation in groups (with critique)												x						x			
Adjust according to critique/inspiration														x		x					
Vote casting		x										x									
Prepare presentation								x													
Pupils read each others' answers																				x	
Presentation in plenum (teacher contribution)			x		x		x	x					x	x		x	x				
Plenum (assessment of pupils' answers)	x	x				x	x	x		x	x				x			x			

Lack of distinct procedures in these lessons is not caused by a lack of will on the part of the teachers. It is caused by the fact that the principle has proved more difficult to implement in certain situations than the literature would suggest. Such situations include, for example, *the reconstruction of everyday settings* in which the pupil is asked to quickly provide the best possible answer; and *art workshops* in which the pupil is asked to paint, draw, write a poem, sculpt, etc. and where the solution requires a series of very small ("nano") abductive actions, that have to be corrected and adapted to each other throughout the process. If one insists on using distinct work procedures in such situations, the risk is that the task will become artificial and drawn-out. Furthermore, it was not possible to document the advantages of differentiation when comparing lessons with and without distinct methods.

Table 13.8 Typical design of a lesson

Model	Activity	Time (70 mins)
Phase 1	Stimuli	5 mins
	Task – presentation	5 mins
Phase 2	Initial idea generation	5 mins
	Analysis	20 mins
	Categorisation	(5–10 mins)
	Initial choice of ideas	(5–10 mins)
	Further development/critique	(5–10 mins)
Phase 3	Presentation	15 mins
	Summary	15 mins

Second, and for a similar reason, it was possible to establish individual brainwriting in only 14 of the 21 experimental lessons. In the remaining seven experimental lessons, pupils were instead asked to mix idea generation, analysis, evaluation, etc. in the creation of *a single* finished answer (cf. the challenge of setting up differentiated work procedures) – either *alone* (lessons 9, 10, 11) or in *groups* (lessons 5, 15, 26). In such situations, one must choose between running the whole process based on the individual or on groups and, while it may seem relevant to conduct idea generation individually, there are advantages in running the analysis part in groups (cf. design stipulation 8). This means that, despite existing research, it is unclear to what extent idea generation should be conducted on an individual basis.

13.6.3 Main Findings from Phase 3 (Abductive Transfer)

Under *Phase 3* of the model for abductive learning, teaching must include a *technical debriefing*, in which the strengths, errors and weaknesses of the pupil's work are discussed. Pupils must take part in several processes to hone their original proposed solution to the task in question. There are three research-supported design stipulations with a special connection to Phase 3 of the model for abductive learning. These stipulations are intended to help teachers (7) structure the pupil's analysis, (8) establish cooperation in the analysis phases and (9) give feedback to the pupil. Findings from the study's experiments in Phase 2 suggest several main conclusions with respect to the design of analysis, cooperation and feedback.

First, the number of work procedures with analytical content can vary from one to five. In a typical lesson plan, it is possible to devote only 5–10 min to each of the work procedures (see Table 13.8).

This makes it difficult to make use of the highly structured analysis techniques recommended in the literature (such as matrices, SWOT analysis, etc.), according to which advantages and disadvantages of all the chosen ideas are systematically listed. Instead, various critical, intuitive analysis phases were used.

Second, it seems that a large number of distinct analysis phases does not create better educational outcomes than a small number of distinct phases (which is

Table 13.9 Number of work procedures with analytical content seen in relation to outcomes

Task	Experimental lessons	Motivation	Abductivity	Technical learning	Creativity	N
Control lesson	12, 16, 17, 21, 23, 25	Reference	Reference[a]	Reference	Reference	129
Low frequency	6, 9, 10, 11, 20, 26	0.45	1.74*[b]	<0.04	1.71	136
Medium frequency	1, 4, 18, 19, 24	0.07	1.54**[b]	<0.47	1.16	80
High frequency	2, 3, 7, 8, 13, 14, 15, 22	0.12	1.83**[b]	<0.34	1.31	141

Letters in a series (a, b, c) indicate a significant difference between various reference points
* $P<0.05$ and ** $P<0.001$

assumed in design stipulation 7). This can be seen in Table 13.9, which categorises the experimental lessons based on number of analysis phases (high, medium and low frequency).

Pupils' own detailed answers suggest several possible explanations. For example, a large number of disparate work procedures can create confusion and unrest in a lesson lasting 60–90 min and mean that pupils do not have the chance to concentrate on the longer work procedures. In the same way, where lessons feature a lot of work procedures, pupils typically work on several different questions and are thus subject to greater pressure, which may hinder the attainment of positive results. Moreover, pupils do not always make a clear distinction between the various work procedures, repeating some types of work and finding that some procedures are unproductive.

Third, it would appear sensible to set up cooperation (e.g. working in groups) in the analysis phase. Cooperation in the analysis phase is one of the traits of the 21 experimental lessons that pupils most often volunteer to comment on (even though they are normally fairly sceptical about group work in general). The need for work in groups perhaps arises because pupils do not know the answer to the task in advance, cannot find it in the book, are uncertain of their own answers and can therefore see the benefit of working in groups during experimental lessons. In comparison, group work is traditionally used for classes where pupils are asked to give answers on reading they have done at home and thus should not in fact need each others' help, if they have done their reading. The above is reinforced by teachers' statements. For instance, Kira says:

> *… I think their most positive reaction – almost irrespective of class – was when allowed to view each other's work. This is where the best outcome can be found (…) inspiration in technical matters has a very significant effect for them.*

Anders adds:

> *… they realise that what they are doing is meaningful and will be used in other situations, because other groups will continue to work on it or comment on it. This also creates an obligation so that they feel 'we'd better do something good.*

Cooperation is also relatively easy to establish in the Higher Preparatory Course. Classes typically have a suitable number of pupils (20+), tables and chairs are

Table 13.10 Is it important for the teacher to explain which answers are right or wrong at the end of the lesson? (N = 194)

Very important	Important	Of some significance	Slightly important	Not at all important
62 pupils	65 pupils	47 pupils	15 pupils	5 pupils
31 %	32 %	25 %	8 %	3 %

movable, groups can go into break-out rooms and pupils are accustomed to working in groups. Furthermore, the analysis phase lends itself to group work *after* idea generation by individuals and *before* a plenary session. For example, groups can distil a large number of individual ideas down to a few group ideas, which are easier for the teacher to handle in the plenary session.

Fourth, it would seem advisable to give concluding feedback – which should include an opportunity for the pupil to evaluate the quality of their own work – where pupils have attempted to create new proposals. Only 11 % of pupils involved in the project gave the answer "slightly" or "not at all" to the question *"Is it important for the teacher to explain which answers are right or wrong at the end of the lesson?"* (see Table 13.10).

Pupils typically explain why they welcome feedback by saying that it means they *"… don't go home with the wrong understanding of things", "… can correct mistakes and be guided towards the right methods", "… know what the right answers are and are thus prepared for the exam"*. However, there is some variation in pupils' appreciation of feedback depending on the individual lesson. Part of this may be due to the different types of knowledge in various subjects and disciplines. Feedback seems most needed in scientific subjects and least needed in the arts and humanities (see Table 13.11).

Besides this, there can of course be differences between individual subjects. This depends, among other things, on the type of knowledge being worked with in the specific lesson. Research into the way teachers should deliver their feedback is scant (Meyer, 2010) and the findings of our study and the experimental lessons are not able to contribute very much. Pupils say that feedback need not always be given at the end of the lesson, that it should be balanced with other learning elements, and that the teacher should try to focus on the positive contribution made by pupils.

13.7 Main Conclusions

The empirical study referenced in this chapter had two overriding and interconnected goals.

- First – it aimed to design and implement practical education products etc. in natural and complex learning contexts that would help pupils tackle and solve real practical problems.
- Second (and based on the first goal) – it endeavoured to develop evidence-based theoretical concepts that would extend beyond the specific findings of the context in which they were refined.

Table 13.11 Feedback in relation to discipline

Discipline	Feedback
Humanities	Reference[a]
Natural sciences	0.77**[b]
Social science	+0.40*[c]

Letters in a series (a, b, c) indicate a significant difference between various reference points
* $P<0.05$ and ** $P<0.001$

The first aim is secondary from the point of view of research and is primarily a means to try out certain design stipulations in the effort to gain a new understanding of issues concerning creativity – this effort being the ultimate objective of the study.

13.7.1 Practice (Practical Education Products)

With respect to practice, the study points towards what we may call an 'abductive didactics' model. This model holds that pupils should be given subject-related tasks that challenge them to engage in meaningful abductive reasoning, as relevant to the subject. At the same time, there should be a (concluding) reference to the existing answers provided in the field, perhaps by means of a debriefing phase with teacher input. It does not need to be more complicated than this. Therefore, the development work illustrates that sometimes we have to go the long way round to come to a simple conclusion.

Abductive reasoning exercises are (of course) already in use in the gymnasium. It is in fact impossible to conduct a lesson without *some* pupils on *some* occasions using abductive reasoning to seek an answer, without being certain of their knowledge or the conventional method. For example, teachers often set tasks that cover material that has not been read or that refer to reading material where the pupil may not remember the facts. When designing suitable educational activities for the purpose, the educational scientist must essentially investigate the best way to incorporate in their design abductive work procedures that take account of various teaching goals.

The study has:

- shown that it is possible to incorporate abductive procedures without compromising the learning goals of the discipline. This does not have to be complicated.
- underlined the importance of considering the way procedures are designed, in order to gain the best possible benefit. Often, a lesson is successful when abductive work procedures are formulated with *imaginary* elements (as opposed to "real problems") in areas in which pupils have *uncodified knowledge* and when *cooperation* and *concluding feedback* are incorporated in the analysis phase.

- shown that one cannot take the nine design stipulations as a detailed nine-point manual that dictates how teachers should act when setting out to promote creative skills and subject-related learning goals. The classroom is not a straightforward cause-and-effect system. Some of the best-recognised principles for fostering creativity – such as distinct work procedures, deferment of assessment, individual's idea generation and structured analysis techniques are often impossible to apply or unsuitable in specific educational contexts in the gymnasium. This may be due to the nature of the subject, the length of the lesson or the difficulty of combining these principles with other design stipulations.

The very general conclusion to the project is thus that *teachers* must feel their way forward and notice what works in practice in various contexts when considering the above recommendations. They may consider the results as professional tools to enable reflection, which may be consulted when planning specific lessons with the stated aims.

13.7.2 Theory (Theoretical Concepts)

It is difficult to make a clear distinction between the outcome of the study's attempt to improve *practice* (that is, the didactic model with design stipulations) and the general insights concerning design stipulations, which the study subsequently attempts to consolidate in domain-specific *theories* (design *principles*). The practical aim of the study was thus to identify, examine and adapt more general design stipulations that teachers could use subsequently as an overall framework or model for designing specific lesson types. It is therefore hard to differentiate between such a practical aim and the primary theoretical aim of the study – namely, to develop evidence-based theoretical concepts (design principles).

The above findings concerning the nine design principles can also be taken as theoretical contributions in the above sense. Besides these findings, one can also draw a series of more general theoretical and methodical conclusions as milestones in relation to research in this field. These relate, among other things, to:

- how to *define* and understand creativity in an educational context
- (= as a proposal formulated by the pupil that has been arrived at through abductive reasoning and is a meaningful response to the task from the point of view of the pupil);
- how one can *study* creative skills in an education context
- (=as the pupil's experience of the need/pressure to use abductive reasoning rather than, for example, the number of ideas generated);
- how to view the *conflict* between creativity and technicality (and internal/external motivation)
- (=using the perspective of differentiation rather than the perspective of harmony or disharmony);

- which *procedures* should be focussed on when trying to promote the two learning goals
- (=the three phases in an abductive didactics model rather than the eight phases in Mumford's CP model).

In conclusion, one can ascertain that researchers should examine the theoretical relation between creativity and technical learning goals while bearing in mind the complexity and the traits of a particular situation that seem to characterise the relation. Hence, the subject that is being taught, what pupils know about the subject in advance, what type of technical knowledge pupils must work with (e.g. introduction, summary, etc.), how often pupils can be motivated to take an active part and how long it takes the teacher to prepare this type of lesson, etc. are not insignificant considerations.

13.8 Limitations of the Analysis and Future Empirical Work

In conclusion, it is now the intention to examine more closely the survey's *research perspectives*, taking a special look at what future, additional research studies the above results and limitations could point to. In this connection, a distinction is made between the studies which have a different *subject area* (e.g. one subject or one class), and studies that use other *methods* (e.g. quantitative tests and qualitative pupil interviews).

The subject area of the study is basically all subjects and academic topics, etc. It goes without saying that it is not possible to cover this whole subject area with 21 trial lessons. This means that the study (at best) can only say something specific about the academic topics, design assumptions, etc., which the teachers select for trial lessons and from there they must try to say something indicative about which lesson types are most useful for the dissertation's model and design assumptions and thus may be expected to be able to be extended to. In an effort to say something in more detail about the opportunities and challenges within <u>a single subject</u>– for example, examining how often the process can be used successfully within one specific subject – it could be interesting to select one subject for a further study.

In order to say something in more detail about how great an effect learning activities create in the long-term, and how much of the daily lessons they should take up, it could accordingly be interesting to investigate <u>one class</u> which for a longer period of time received abductive instruction from all of its teachers in all lessons.

The study's *investigation methods* are primarily oriented around a questionnaire interview with pupils in connection with the trial and control lessons. In an effort to say something in more detail about which design principles work, when and why, in relation to the different types of pupils, it would be possible, for example, to supplement the above studies with <u>qualitative pupil interviews</u>. For example, by following up the different trial lessons by appointing two interview groups – a group of pupils who are most positive about the teaching method, and a group of pupils who are least positive about the teaching method. This could help to indicate what might possibly be changed if different groups of pupils are to learn more through the teaching method and why it might work better with regard to some lessons and pupil types than others. In an effort to establish more reliable, quantifiable data with respect to the trial teaching, one could also establish permanent trial classes and permanent control classes (with the same teachers, subjects, etc.) and continuous measurement of progress in the two groups (e.g., with regard to academic learning, the ability to solve relevant problems, etc.). Such an approach with quantitative testing could to a greater or lesser extent be structured as a randomized, controlled study. Among other things, this will make it easier to measure the desired effects – such as the development of creative skills – over a longer period than is possible with individual lessons of 60–90 min. The challenges inherent in such an approach are comprehensively covered in the existing literature.

13.9 Appendix: Ten Abductive Openers

1. **Explanation**

   Explaining the connection behind observed phenomena. For example, by selecting a cause, rule or regularity that can explain or predict one or more individual situations.

   Examples:

   - Why do some things sink while others float?
   - Why are terrorists willing to die for their faith?
   - What principle is … the common denominator in the following 5 sentences?
   - Why do certain animals have the colours that they have?
   - Why do we use proverbs and sayings and what do they do with the language?
   - What would happen … in Afghanistan if … the Allies withdrew?

2. **Interpretation**

   Interpreting how a given message should/could be understood. For example, by finding meanings in situations where the understanding/meaning is not necessarily visible or follows from the pure linguistic meaning of the words.

   Examples:

   - How can the following text excerpts be interpreted....?
   - What does Hans Christian Andersen want to say with…?
   - What is meant by the following English expressions: "*To have ants in one's pants*".
   - What did Plato mean with his parable of the cave?

3. **Analogy**

   Comparing/describing/explaining "something" with "something else". For example, transferring the characteristics of one context to apply in another context (e.g. the perception of society as an organism).

Examples:

- Find a different context where knowledge about … "bipolar power" can be used.
- Describe democracy (to the ignorant) without using the following words: *majority, all, part.*
- Create an analogy that can explain the concept of "gravity".
- Create mental recall rules for the chemical symbol for lead (PB) – for example, Plum Bum.

4. **Definition**
   Defining a concept – including the assembly of a number of individual cases into a new concept.

   Examples:

   - Give a definition of the concept…. (energy, democracy, faith, adventure, etc.).
   - What do you think characterizes the following concepts…. (energy, democracy, faith, adventure, etc.).
   - Categorize the following individual cases into certain groups/concepts…: e.g. political attitudes, living beings, and chemical elements.

5. **Investigation**
   Devising a (new) way of investigating or experimenting with certain phenomena.

   Examples:

   - Devise a method that can investigate/clarify… high school culture.
   - Devise a method that can investigate/clarify… whether people are believers.
   - Devise a method to investigate/calculate… the law of gravity.
   - Devise a method to investigate the importance of getting… liquids, sleep, etc.
   - Devise a method that can investigate… the meaning of life ☺.

6. **Simplification**
   Reducing complex phenomena and contexts. For example, by devising ideal types, models, heuristics ("rules of thumb"), examples or simplifications.

   Examples:

   - Explain … the law of gravity to a child in kindergarten.
   - Create a *model* of … what determines the positions of the political parties.
   - Give rules of thumb for what typically explains … a person's religious nature.
   - Give *examples* of … what a street child must experience in a single day.
   - Describe what characterizes a *typical*… high school pupil (or Muslim).

7. **Problem**
   Developing products, processes, laws, etc. that can solve specific challenges/problems.

Examples:

- How can we solve the problem of … poverty, climate?
- How should you create … an economic system on a desert island (a new EU, a new religion)?
- How can you create … wind turbines that can operate in a desert landscape
- How should Obama tackle the relationship with Russia?
- Imagine … that you are Hitler and have to convince the people that they have to go to war.

8. **Story**
   Creating free stories. For example, on the basis of certain keywords or perspectives (stimuli).

   Examples:

   - Create a meaningful narrative from the following 5 keywords…
   - Create a story in a certain style… for example, a fairy tale…
   - Imagine that you are…
     - *an ethnologist* who is observing how an unknown tribe worships their god (what happens?).
     - *a researcher* who discovers gravity on an alien planet (what characterizes it?).
     - *God*, who has to design atoms on a new planet (what characterizes them?).

9. **Formulation**
   To use one's motor perceptual (silent) system to form certain thoughts, desires, goals, etc. or to reshape concrete/abstract knowledge into alternative forms of expression.

   Examples:

   - Draw, paint, build, mime, dance, act out, etc. a concept (democracy), a theory, etc.
   - Rewrite a message in a certain style, such as a political speech, newspaper, lyrical poem, etc.
   - Write a free sentence (10–20 words), which uses the tone of a certain style.

10. **Body**
    Using one's body in ways one has not previously done. For example, on the basis of certain keywords or perspectives (stimuli).

    Examples:

    - invent a new dance, way of walking, double backhand, high jump technique, drum style, way of talking, sleeping, eating, etc.

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Chapter 14
Creative Imagination *in* Memorization in Mathematics Learning

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Abstract Creative imagination and memorization are complementary abilities in learning mathematics (Vygotsky, J Russian East Eur Psychol 42(1):7–97, 2004). These complementary abilities engage "movement" in learning mathematics among "realities" (e.g., personal and social experience, emotion, and cultural practices) (see also Dewey, Experience and education. Touchstone, New York, 1938/1997). Creative imagination in memorization "embraces" forces of contradictions (e.g., differentiation, convergence, and emergence) (see Tan, Creativity in cross-disciplinary research. In: Shiu E (ed) Creativity research: an interdisciplinary and multidisciplinary research handbook. Routledge, London, pp 68–85, 2013; Tan, Teaching mathematics creatively. In: Wegerif R, Li L, Kaufman J (eds) The handbook of research on teaching thinking. Routledge, London, pp 411–423, 2015). Possibilities as the core of creative learning in mathematics unfold in purposeful, playful, non-structured, social, and ethical activities (see Craft, Curric J 10(1):135–150, 1999).

14.1 Introduction: Imagination and Functions

This chapter aims to present our views on the relationship between imagination and memorization in the context of mathematics learning. The chapter begins with a British mathematician *G.H. Hardy's* (1877–1947) narration on the extraordinary imagination of an Indian colleague, *Srinivasa Ramanujan Iyengar* (1887–1920).

"I remember going to see him once when he was lying ill in Putney. I had ridden in taxi-cab No. 1729, and remarked that the number seemed to me rather a dull one, and that I hoped that it was not an unfavorable omen. 'No,' he replied, 'it is a very interesting number; it is the smallest number expressible as a sum of two cubes in two different ways.'" (p. 147)

In Hardy's (1937) narration "(Ramanujan) could remember the idiosyncrasies of numbers in an almost uncanny way" (p. 147). Their colleague, John Littlewood

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(1885–1977) acknowledged Ramanujan's special feelings toward numbers. According to Hardy (1937), the former commented that "every positive integer was one of Ramanujan's personal friends" (p. 147). Hardy (1937) elaborated the unique ability of Ramanujan with reference to their casual dialogue on the number: 1729. In the footnote, Hardy (1937) included the equation of the number and the sum of the two cubes in two different ways: $1729 = 12^3 + 1^3$ or $10^3 + 9^3$.

The principle of complementarity is considered in describing the relation between imagination and memorization. Complementarity embraces general observations and features of individuality (see Bohr, 1950). *Hardy* (1937) observed the number plate, and recalled it (memory or memorization) with a bypassing feeling of "dullness". His narration on the dull number plate turned out to be a creative discovery in mathematics. The narrator's (Hardy) experience of observing the number plate and his individualized feeling of "dullness" transformed to social experience of the active listener (Ramanujan). This social experience enriched imagination of *Ramanujan* when he connected it to his personal experience with numbers. The social interaction of the two like-minded people with diverse backgrounds was essential for creative experiencing, memorizing, and imagining.

Imagination is a faculty from which ideas emerge (Hume, 1739/1896). It is a reality in which emotions exist and a prerequisite for creativity (Vygotsky, 2004). A construct of an imagination represents something substantially new, never encountered before in human experience and without correspondence to any object existing in reality (Vygotsky, 2004, p. 20). Once it is externally embodied, or given material form, the crystallized imagination has become an object, existing in the real world and affecting other things. A function of imagination is looking at things through another's eyes or eyes of human species to discover "some latent tendency or possibility in the development of the object" (Kudriavtsev, 2002, p. 25). Another function of imagination is to build "a dialogue on an equal basis in which there is always place for both agreement and coincidence of position and contradiction and dispute and discussion – with another person, or group of people, with mankind, with the Absolute, and, ultimately, with oneself." (pp. 27–28) This function "allows for the interpretation of this tendency as the mode of interaction of those heterogeneous and disparate parts that constitute the whole" (Kudriavtsev, 2002, p. 25). Ramanujan's imagination penetrated Hardy's eyes and discovered the possible relations of two sets of cube numbers within 1729.

Imagination is a faculty of ideas (Hume, 1739/1896), and memory is a faculty of impressions. Ideas and impressions are two observations of perceptions. While ideas possess the characteristics of general, faint, and low in energy, impressions are salient like emotion and passion (Hume, 1739/1896). The title of this chapter uses the preposition "in" twice. "*In*" in italic briefly represents complementarity of two creative abilities namely imagination and memory (Vygotsky, 2004). "In" in print concerns continuity and interaction of learning experience.

The world of mathematics has its basic principle in intuition or direct experience (Nishida, 1911). The number "1729" is an intuitive experiencing of Ramanujan as he directed the number to the relations between the two cube numbers (e.g., $1^3 + 12^3$). Experiencing creativity adheres to the principles of interaction and continuity (Dewey, 1938/1997). On the continuum of creativity experience, imagination is enriched by memorization, and vice versa (Vygotsky, 2004). Imagination, a basis of creativity, is a reality; and memorization as a form of experience (social, personal) is another reality. Creative imagination interacts with existing skills and knowledge (expertise, memorization), and transforms itself to the acceptable forms of product.

Three mechanisms are essential in experiencing creativity, namely divergence, convergent, and emergence. Divergence is broadening and expanding; convergence is building and narrowing; and emerging is transforming and renewing. While imagination is divergent and emergent, memorization is convergent and emergent. Emergence of imagination is based on our (own) experience (Vygotsky, 2004, p. 17), in the case of Ramanujan, with the beautiful numbers, elements or materials in reality (personal), whereas in the case of Hardy, the experience with the uninteresting number (social) (Vygotsky, 2004, p. 13). According to Vygotsky (1978), the perception of the external (e.g., the number plate) and the internal (e.g., knowing of the properties of numbers) is the basis of our experience. The child's imagination is realistic and is about seeing the whole before the part (Kirkpatrick, 1930). The richer the experience one has the richer is one's imagination. Experience from the others is another base of imagination (Vygotsky, 2004, p. 17). The person's imagination is broadened by reading and listening to other persons' narrations (Ramanujan's social contacts in the British and Indian communities of mathematics) and descriptions through multiple media of communication such as oral histories, newspapers, and webcasts.

Emotional elements exist in all creative imagination. The construct of an imagination evokes the feeling, a real experience. A feeling or an emotion seeks a specific image that corresponds to it. In the case of Hardy, the image of the number plate (1729) was associated with the feeling of dullness. For Ramanujan, the feeling of interesting was related to the number plate to the sum of two cube numbers. According to Vygotsky (2004, p. 17) the feeling has the capacity to make impression on the specific image that resonates with the mood of the person at a particular moment. Creative imagination is regulated by emotion, desires, and purposes (Kirkpatrick, 1930). Toddlers of 18 months or earlier begin to attend movement, music, and play groups. They are led to bodily creative movement or imagination in action (Vygotsky, 2004). Singing songs with number (1, 2, 3, 4, 5, …), they move physically according to the flow of writing out a number. Children who are between 3 and 6 years old are at the stage of free play of imagination (Kirkpatrick, 1930). Children can take turn in show and tell or play and act on the relation among objects in comparison (e.g., A has more balls than B has; C is taller than D; E is the shortest among all). Between 6 and 12 years old children construct the distant world of reality and perhaps revealing in the fairyland. From 12 years old onwards the real world is the theater of imagination.

14.2 Stages of Creativity

The essence of mathematics (算数 *shuanshu*,counting and numbering) is thinking creatively beyond arriving at the right answer (Mann, 2006). Knowledge of mathematics can be defined as information and know how (Polya, 1962), of which the latter is more important than the former. Acquiring knowledge in mathematics is essential as it sets a ground for knowing mathematics. Mathematics learning is essential for living and growth, it shall relate to the art of acquiring types of knowledge for practical life, scientific endeavor, and systemic innovation. Mathematics education aims to guide the child to acquire the art of utilization of cumulative knowledge of existence (e.g., *contemplative-explanatory, descriptive-empirical*, and *active-transformative*, see Ponomarev, 2008b). Contemplation creates concrete knowledge that grows out of practice and common sense in undifferentiated models from the observed phenomena (Ponomarev, 2008b, p. 16). The represented is directed known and experienced. The person explains to the others exactly the way s/he has understood. Intuition-based and consciousness-based creativities are stimulated by curiosity, philosophical needs of the society, immediate experience, and contemplative-explanatory knowledge. In recount the “magic-like” imagination Kolata (1987) mentioned that Ramanujan left behind three notebooks with as many as 4000 results. Discovery or generation of mathematical theorems is an intuitive engagement (Hardy, 1937). There are multiple explanations to the creative imagination of Ramanujan. In his early years, Ramanujan learned independently the what is and how to do mathematics, and referred to a textbook, which outlined an extensive list of theorems without proofs. He likely adopted this style of presentation of mathematical theorems. As a Hindu devotee, Ramanujan credited the flow of imagination to the presence of godlike experience or contemplation.

Description and experimentation create generalized knowledge that grows out of direct response to one or another social requirement of practical need (Ponomarev, 2008b, p. 18): ‘The investigator exerts an influence on the phenomenon, taking into account only his own function in the interaction with the cognized object and does not yet encompass the interaction in its entirety’. Regularity suffices to solve repeated problems. Active transformative knowledge grows out from solving problems with multiple forms of complexity, at the abstract level and requires modeling.

Culture transforms nature to suits the ends of man (Vygotsky, 1929). Memorization based on the use of signs is an instance of all cultural methods of behavior. Creative imagination emerges in all stages of life and from creation of signs. Creativity development unfolds in multiple stages (Ponomarev, 2008a, *background, reproduction, manipulation, transposition*, and *regimentation*). In each stage of development, imagination takes its form differently, from perceptual to logical. Imagination is the most intuitive (emotional) at the *background* stage. Thinking is within the practical problem solving sphere (e.g., the taxi’s number plate). Actions with the objects are original without the mediation of logical programs. Systems of actions are constructed without reliance on rules of logic, unconsciously, on the basis of emotional evaluation. At the stage of *reproduction*, the learner solves the problem using the external plan (like that of the *in growing* stage of cultural development, see Vygotsky, 1929). The learner can reproduce an external plan given to him(her) verbally. At the stage of manipulation, the learner solves the problem by manipulating representations of objects. S/he reproduces the internal plan of action by first performing it on the external plan. The learner experiences often "loss of problem".

At the stage of *transposition*, solutions are found by manipulating representations of objects. When the problem is attended for the second time, the path known provides the plan of action. At the stage of *regimentation*, the learner controls the actions consciously. Actions are systematic and constructed according to a scheme (e.g., two possible sets of cube numbers). A plan or program for a system of actions is constructed at the start of problem solving. Each action corresponds with the requirements of the problem.

14.3 Creative Learning and Activities

Complementary abilities (memorization, imagination) in the context of mathematics learning is further understood with reference to Craft's (1999) vision of learner-inclusive education, which regards "possibility thinking" as a core of creative development of early years. There are three principles of "possibility thinking", namely celebrating convergence *in* divergence (Tan, 2013), using imagination to generate ways to solve a problem, constructing more than one solution (not stopping at one) to the problem; encouraging emergence such as posing questions naturally; and engaging in effortful creativity such as non-structured, experimental and social play. The child who learns about ratio, for instance, understands the relationship of two numbers in comparison (e.g., 3: 4). S/he applies the information of ratio to the social contexts and reflects upon it in making necklace of different patterns and colours. In a bag there are red and green beats. To make a necklace according to the ratio of 3:4, s/he has the possibility to repeat the pattern of three red beans to four green beats, or that of three green beats to four red beats. Further s/he can vary the lengths of the necklaces in different ways, randomly (non-structured), according to the persons s/he has in mind (experimental) or in the context of social play with the other children. Divergence includes for instance *differentiation*: dissociation, distortion or change, analysis; convergence is about *integration*: association, combination, synthesis; and emergence concerns *transformation:* crystallization or embodiment. Divergence and convergence are related to a positional change of a set of elements; and emergence concerns a shift in the position of change of a set of elements (Kastenhofer, 2007). The child can change the ratio of the beats and the length of the necklace (divergence) within the same product (convergence), or s/he can change the ratio and/or the type of product (emergence).

Creativity begins with reworking on the content or dissociation of impression and continues with what Valsiner (2013) termed as "a dialectical synthesis of a new set of inclusively separated opposite (analysis-synthesis conjoint)". To enhance cross-curricular, learner-inclusive education, Craft (1999) suggested engagement in making meaning, connections, and stepping beyond what is to what could be, providing opportunities and models for playing together and playing independently, creating time for playing during lessons, play-times, at the playground and dinner halls, and knowing some children will find it easier than others in committing to possibility thinking. To expand learning of ratio, the child is given tasks of distribution, for instance sharing a certain amount of food (e.g., 500 g of sweets) with three children according to a given ratio (3:2:5), Cross-curricular creativity includes playing through for example "puppetry, dramatic play, role-play, open-ended scenarios, improvisation, empathy work, …, brainstorming, storytelling." (Craft, 1999, p. 146) In line with the understanding of complementary abilities and the cycle of learning (Whitehead, 1929), four creative learning and activities for possibilities in mathematics learning are presented (Craft, 1999), namely, purposeful learning in the context of zone of proximal development, playful learning during preschool years, non-structured activities in everyday life, and social and ethical activities for positive growth.

14.4 Purposeful Learning

The word "learning" carries multiple connotations (*dictionary.com*): Grasping or mastering knowledge and skills, memorizing (learning by heart or rote), and discovering something different from that of the current practice. In each set of the meaning of learning, there exist complementarities in human abilities (memorization and imagination), environments (the external and internal), and outcomes (self-expression and cultural embodiment). To acquire abilities to imagine, memorize, create, and the like abilities, the child learns (学, *xue*) by engaging all senses or the whole being including, the body (身, *shen*), the speech (口,*kuo*) and the mind (意,*yi*) (Tai, 1989). Learning is intuitive, social, and cultural. In learning the whole being meets the other whole being; and together in full engagement a relatedness of learning emerges (e.g., a unit of care comprising the mentor and the mentee, the teacher and the student, or the adult and the child). The adult of the relatedness recalls, reproduces, and creates structure, while the child of the relatedness observes, discovers, and imitates the act of counting and the possible relations of materials use in performing the act. Learning to reproduce through imitation is characteristic of the *natural* and *naive* stages of development (see below, Vygotsky, 1929). In play and likewise activities the child re-experiences (discovers) the adult's behavior in his(her) imaginary world, and encounters a qualitative change in his(her) understanding of the social behavior. Learning to imagine in movement in the play world is characteristic of *growing* and *internal* stages of development (see Vygotsky, 1929, and elaboration below). With a scientist's reflective lens, we investigate the existence (ontological) and the relationship of knowledge of existence to the existence itself (epistemological, the representation to the represented, Ponomarev, 2008a). With a philosopher's contemplative lens, Ramanujan penetrated the truth and the concrete, encountered the self-other interactions with Hardy, as well as see and act on things (acting intuition) or two possible cube numbers (Krummel, 2012).

Purposeful learning is about learning from the other people in the relation that is open and that is in the form of speech (see Buber, 1937). The purpose of learning is to think culturally (see Vygotsky, 1978). Accordingly, purposeful learning is about developing the capacity of higher functions. To Vygotsky (1978), “all the higher functions originate as actual relationships between individuals.” (p. 57), and “(e) very function in the child’s cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (*interpsychological*) and then inside the child (*intrapsychological*). This applies to voluntary attention, logical memory, and the formation of concepts.” (Vygotsky, 1978, p. 57) The word “originate” shows that learning is about a transition from authentic, realistic, or concrete relationships to the imaginary (numbers/beats → two sets of relation of cube numbers/a necklace). The sequence of “first, then” denotes the direction or “movement” of learning from the external to the internal and from the experienced to the novice.

Goal-directed behavior (Ponomarev, 2008a) is crucial in deliberate or purposeful learning. Vygotsky (1929) elaborated that the child acquires the arithmetic ability first by natural arithmetical endowment (at the *natural* stage of cultural development) such as the comparison of greater and smaller groups and sequencing of events (first, second and so on; now, then). The child learns to remember pieces of information by natural means according to the degree of his(her) interest in them. The amount of information that s/he remembers is determined by his(her) attention and his(her) individual memory. The child imitates adults and repeats “one, two, three …”, but does not know the purpose of counting (the *naive* stage of cultural development, Vygotsky, 1929). S/he counts with the aids of fingers; and finally s/he discards the use of fingers when counting is effected in the mind. The child is at the *naive* stage of development, a transitory stage, from which the child enters into the *further* stage of development quickly.

The child learns to remember pieces of information using some pictures and their corresponding words. S/he hears the words and looks at the corresponding pictures. S/he remembers the whole list of words with the aid of pictures. Vygotsky (1929) termed the use of pictures coupled with corresponding words as the *mnemotechnical* method of cultural behavior. When a new set of words presents before him(her), the child notices that the *mnemotechnical* method is insufficient, as the words do not correspond with the set of pictures s/he possesses. After a few trials and errors, the child employs the external cultural method. S/he discovers the natural association between the picture and word, and quickly transits to creation and formation of new associations. The child is at the *growing in* stage of development. *Finally*, by means of a *sign* the child passes from the external to the *internal* stage of development. A sign (S) creates a conditional-reflective process connecting two pieces of information (A-B, i.e., SA, or SB). New features (SA, SB) consist in the structure of the cultural method of mnemonics.

Purposeful learning is social-culturally creative. Vygotsky’s (1978) zone of proximal development (ZPD) refers to the space of appropriation in which the adult (mentor) guides the child (mentee) from his(her) actual level of development to attain the next proximal level of development. The mentor "awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his(her) environment and in cooperation with his(her) peers" (Vygotsky, 1978, p. 90, her added by the author of this chapter). The ZPDs serve as social units of creating environments in which qualitatively transformations occur (Holzman, 2010). In the purposeful learning context, the teacher establishes coherence in contents, instructions, and activities, an example of convergence in divergence. S/he attempts to appropriate roles as s/he moves from the actual level of development of the child to his(her) proximal zone of development: As a collaborator, an interpreter, a partner, a mentor, and so on. Congruence in roles is an example of convergence in divergence (Tan, 2015).

14.5 Playful Learning

Etymologically, in the Chinese language, play has multiple connotations which include "returning to the original" (*wan*, 玩, comprising the left radical, king and the right radical origin), "flowing into the space of challenge with the other" (*youxi*, 游戏, the first character has three parts, the left most radical water, the middle part space, and the right most person; the second character is often used referring to play, theater, or show). Play refers to rapid movement, a gesture, risk taking, homage, attending to and caring for others (Huizinga, 1938/2004).

In teaching geometry to the 12 year old students with learning difficulties, a mathematics teacher adopted the role of a captain and invited some students in the class to become leaders in small groups. The captain of the ship announced the start of a journey to the virtual reality of experiencing shapes (geometry), their properties (180° for the sum of three angles in a triangle). In the small groups, the student leaders managed the tasks of identifying shapes and of searching for stable shapes in real life objects (e.g., the stand of a table in the form of triangle for ironing clothes). The teacher who facilitates play-based mathematics learning noticed the cyclic phases of *romance* (questioning, free discovery, love of learning), *precision* (memory), and *generalization* (applying knowledge and returning to romance) (Whitehead, 1929). The child needs external attention for instance scaffolding and internal reflection when the brain is at "rest" for instance during play and quiet time to reflect (Immordino-Yang, Christodoulou, & Singh, 2012). Referring to the cycle of pedagogy (Whitehead, 1929), joy of interaction serves as a mean (phase of *romance*) and an outcome of learning (phase of *generalization*) which broadens the mind and which builds resources (Fredrickson, 2001) for positive growth (Dewey, 1938/1997), self-actualization (Maslow, 1954), and personhood (Rogers, 1961).

Play emerges, during the preschool years, when the unsatisfied desires and tendencies that cannot be realized immediately make their appearance (Vygotsky, 1933). In play, the child enters into imagination in action and creates the speech that s/he recalls from everyday life (e.g., how the teacher solves a two-tier mental sum).

Encountering the role in play, the child re-experiences the feeling in action, reconstructs the social gestures, as well as re-calls and imitates the sounds, tones, sentences, stories, etc., related to the role of his(her) choice. Play is a form of imagination in action (Vygotsky, 1933), just like dramatization, singing, dancing, making, drawing, and so on. Learning in play is a creative improvisation (see Ingold, 2013).

The basic criterion of play is the imaginary situation, i.e., the space between the real (optical) and sense (imaginary) fields (Kravtsov & Kravtsova, 2010, p. 29). The imaginary situation with the number 1729 (real) was the sense of the relations of two cube numbers to the feeling (interesting). In the slides of presentation, the pictures in the different objects set the imaginary sense of learning geometry authentically (optical/real). To create this space, the player has to be "inside" (e.g., the role as a captain, or the leader) or "outside" of the play (e.g., the role as a mathematics teacher or the learners) (Kravtsov & Kravtsova, 2010). The child, as a player, understands positioning or the self in different situational space. Positioning allows the child to learn to view the situation in more than one perspective at the same time. Play that leads development is rule-based (Vygotsky, 1933).

14.6 Non-structured Activities

With reference to Hodkinson's (2005) theoretical view, mathematics learning is social, relational, and embodied. To him, learning engages the mind and the body. Learning is both a value-laden process and a product of curricular contents. The process of learning is itself a product of learning, and vice versa. There is inseparable between formal and informal, as well as general and specific learning (Hodkinson, 2005). In a recent review, it is reported that "latent" learning occurs, when we are present in the environment without deliberate and active engagement in the objects and things around us (Soderstrom & Bjork, 2015). There is a converging view that overlearning is not redundant. Instead it is beneficial for long term memory (Soderstrom & Bjork, 2015). The review supports among others the views that the unperceived part of a collateral action is more important in creativity development than the local and deliberate part of the action (Ponomarev, 2008a). It also echoes Bergson's (1911) understanding of the state of relaxation and duration as the core of creative evolution. It clarifies Wallas's (1926) incubation stage of a creative process that the creator walks away or distracts him(her)self positively from the task. Following incubation, the state of illumination or "*aha*" emerges.

Gibson (1979) created the term "affordance" from the verb "afford" referring to the complementarity of the person and the environment. According to Gibson (1979) the affordances of the environment are what it offers, provides or flourishes, either for good or evil. The learning affordances include the physical classroom, the interpersonal environment, the learning materials, the space and duration in which the learners interacts with the contents, with each other, and with the teachers. Availability of affordance does not translate directly to awareness in learning. The task of the teacher is more than to ensure availability of (positive) affordances for learning. The teacher genuinely constructs coherence among affordances that synchronize the rhythms of learning and that raise the level of sensual awareness in learning (see Tan, 2015). Craft (1999, 2012) articulates possibilities to learn from non-structured activities in everyday life, expanding the space of learning to the lived world. The children who participate in daily chores observe how to count and likely find problem sums familiar as compared to their counterparts who do not have likewise everyday problem solving opportunities. Possibility thinking in everyday non-structured activities is the core of applying the skills of computing creatively to solve daily problems. As a core of creative imagination, possibility thinking connects what is in the mind to what can be done in reality. It links what one knows to understand the unknown. Counting is learned in multiple occasions such as in the lift, outside the mall, during the mealtime, and with multiple activities such as singing, playing, and reading. Numbering is grasped through observing the nature such as the number of petals of flowers, parts of body (e.g., insert), and numbers of legs of vertebrates.

14.7 Social and Ethical Activities

Creativity is "an essential condition for existence" (Vygotsky, 2004, p. 11). Thargard and Stewart (2011) postulated that causes of creativity reside in psychological, neural, social, and molecular mechanisms. To them, creativity results from novel combination of representations, which are patterns of neural activity in multimodal modes (visual, auditory, tactile, olfactory, gustatory, kinesthetic, emotional, and verbal) combined in a kind of twisting together (convolution). Every person including the child has the ability to combine existing elements in novel ways. Ramanujan's or the mathematics teacher in the elementary school's imagination was the basis of all creative activities, an important component of all aspects of cultural life that enables artistic, scientific and technical creation (Vygotsky, 2004, p. 8). Memory of Hardy, Ramanujan, or the mathematics teacher has the characteristics of relational, social, dynamic, and plastic structures. As "emerging properties" of information representation (Courtney, 2004), (working) memory likely comprises a network of here and now control and attention signals (Postle, 2006). Self-imagination for instance is thinking of the future (e.g., using the "if, then"). In a study, self-imagination improved prospective memory of memory- impaired patients (Grilli & McFarland, 2011). Imagination alters memory (false memory) (Pezdek, Blandon-Gitlin, & Gabbay, 2006). The brain at "rest" or at the default mode is when "neural processing lapses in outward attention may be related to self and social processing and to thought that transcends concrete, semantic representations and is when the brain effectively monitors and controls tasks- and non-tasks directed states (Immordino-Yang et al., 2012, p. 353).

Tacit knowledge (Polanyi, 1958) relates to emergence of social self (Mead, 1913) in ethical activities. According to Mead (1913) there is then "me" who approves, suggests, and consciously plans or the reflective self. Psychical life is the fullest manifestation of realistic experience (Dewey, 1884). Carl Rogers's (1961) theory of creativity as a process of becoming a person (*zuoren* 做人, making or constructing personhood), suggests "openness to all experiences", "unconditional positive regard", and "freedom to express" as the conditions or "affordances" of constructive creativity. In England, Ramanujan developed a close friendship with Mahalanobis (2010), a statistician. They often spent most Sunday mornings taking a long walk. In Mahalanobis (2010) account, Ramanujan possessed shy and quiet dispositions, and had a dignified and pleasant quality. When asked questions, Ramanujan answered briefly.

Our ability to feel, perceive, and think intuitively (Ponomarev, 2008a) complements our ability to narrate and dialogue in the space of social experience and imagination. The space-between-humans emerges in moment by moment reflection and immediate connectivity to the past through the present and into the future (see Barresi, 1999). Solving socially relevant questions (e.g., distributing the same amount of food to families that lost their home after tsunami incident) is direct, contemplative, and explanatory. What is essential in learning mathematics or a subject matter is the art of learning or scientific research, the craft skills for discovering new knowledge, and the personal form of knowledge how to think and act (Jacobs, 2000). In the case of solving a word question related to food distribution to victims of tsunami: Which family shall receive what amount of food? Mathematical accuracy is a byproduct of reasoning out ethically equality of food distribution of to the two families during the unfortunate and difficult time.

14.8 Conclusion

Mathematics as a subject matter provides opportunities for emergence of spaces of learning in which memorization (*reproduction*) complements imagination (*production*), *convergence* complements *divergence* (Guilford, 1950), and *continuity* of experience intercepts with social *interaction* (Dewey, 1938/1997). Educating orientates the child on his(her) own initiative (with deliberate desire or purpose) to acquire knowledge or develop ability (Zuckerman, 2007). Mathematics education is about cultivation of culture, the thought of activity, and receptiveness of beauty and humane feeling (deep and high, see Whitehead, 1916). An aim of mathematics education is acquiring the art of utilization of knowledge, or understanding knowledge and its usefulness in the present and for the future (Whitehead, 1916). Mathematics learning is also about developing culture and expert knowledge to some special direction (Whitehead, 1916). It involves appropriating scientific and philosophical thoughts, seeing what is general in what is particular (Whitehead, 2012), and knowing what is concrete in what is transitory (Nishida, 1911). The world is part of our goal (Stern, 1917), space (*basho*, Nishida, 1911), and (inter)related systems that co-determines our existence, being, and becoming. It is the place (in Japanese 场所 or *basho*) for "the identity in change" (Jiang, 2005, p. 453). The world "moves" creatively from one form to another form (Nishida, 1979). Complementary abilities

Table 14.1 Complementarity and possibilities in mathematics learning

The world in perception and interaction	Complementarity in abilities, mechanisms, phases, and expertise	Mathematics learning and education	Learning processes and phases	Possibilities in learning and activities
Social, cultural	Abilities, e.g., Memorization in imagination	Intuition, direct experience	How to: The act of actualization of knowledge in practicality	Purposeful learning: Zone of proximal development
Dialogical	Mechanisms, e.g., Convergence in divergence for emergence	Knowing: Cultivating culture and thought	Phases of learning: Romance, precision, generalization	Playful learning: Imagination in action
On a continuum of the past-present-future	Phases, e.g., *background, reproduction, manipulation, transposition*, and *regimentation*	Knowledge: Know how and information	Cultural development: Naïve, growing in, internal	Non-structural activities: Informal learning
Part of goal, space, and relation systems	Expertise, e.g., Contemplative-exploratory, descriptive-empirical, active-transformative	Creative thinking and growth	Complex, social, cultural, embodied	Social and ethical activities: Societal learning

Note. In each column, relevant contents are placed arbitrarily

of creative imagination and memorization (Vygotsky, 2004) relate the past to the present and together they anticipate the future based on the past in the present. In flow (e.g., play, making, and improvisation) the principle of complementarity (Bohr, 1950) precedes the principle of continuation (Dewey, 1938/1997), and mediates the principle of interaction (Dewey, 1938/1997; Ponomarev, 2008a).

In this chapter, creative learning is considered as a relational process and as part of human development. The essence of complementarity of abilities is highlighted in describing experience (memorization) and imagination (creativity) in mathematics learning (see Table 14.1). "Human beings fully emerge as persons … in dialogue or relation with the other beings." (Gordon, 2011, p. 211) The basic word of the *I-It* world refers to our relation to the objects or things; and the *I-Thou* world concerns our relation to the nature, other people and the intelligent beings (Buber, 1937). Complementarity in abilities is related to actual activities and processes of the soul (see Dewey, 1884; Sheridan-Rabideau, 2010; Vygotsky, 2012). Using the approach towards the problem of explanation that is embodied in the notion of complementarity, we are both "actors and spectators in the drama of existence" (Bohr, 1950, p. 54). The new paradigm of psychology of creativity in mathematics learning believes that reality is given in the living experience of the soul's development

(Dewey, 1884). Complementary abilities (creative imagination *in* memorization) (Vygotsky, 2012) and processes (coherence, congruence) flourish the soul. Coherent learning is mediated by tools (technical – e.g., a pair of chopsticks; psychological- e.g., signs) between the agent and the humanized environment (see Kono, 2010). Retrospective and spontaneous memories are in complementarity; they both are emerging properties (Mok, 2014) and function as a coherent basis for constructing creative cognition. According to Vygotsky (2004), our brain is an organ that retains and reproduces previous experience (*reproduction*). It combines creatively elements of the past experience and uses them to generate new prepositions and behavior (*production* or *creation*) (Vygotsky, 2004, pp. 8–9). The plasticity of our neural substance is the organic basic of reproductive activity or memory. Plasticity is an instance of complementarity, which refers to "the property of a substance that allows it to change and retain the traces of that change." (Vygotsky, 2004, p. 8)

Learning to create is a forward making process (Ingold, 2013). In making an art piece (e.g., combining geometrical shapes and lines into colorful patterns of an Indian textile art), for instance, sensual awareness extends to the movement of the hands and to the flow with the material. The mind flows with the movement of the materials in the hands, which lines and shapes changes moment by moment as the materials in the hand unfold gradually the satisfactory form. Learning in realistic experience can be a deliberate social practice that brings shared meanings into existence. Recalling evokes mental images (or materials: silk, ink, crafted wooden blocks with creative design for textile hand-printing) into being and sensual awareness and the flow of materials bring the state of being further into becoming (Ingold, 2013). Ramanujan attributed his creative power in mathematics and mathematics learning to the Goddess Namakkal, his family deity (Rajendran, 2012). Creativity is a process of learning for growth, development for personshood, and love of discovery. The art of mathematics learning lies in how the creative mind innovatively rearranges know-hows (e.g., using a pen and pencil to solve a complicated sum, $1045 \times 3567 \times 9842$) or alters the affordances of the environment which in turn change the learners (e.g., creating a digital device or an *ipad* to conduct simultaneous activities – taking and sending photos, videos, notes, emails, and text messages, Craft, 2012). Learning mathematics shall include becoming aware of diverse observations and the rise and fall of phenomena in real life, and sometimes from the challenging tasks to the simple tasks (Whitehead, 1929).

The chapter concludes with some preliminary insights into mathematical learning for nurturing creative imagination and memorization.

- Recognizing complementarity of imagination and memorization on the continuum of creative experiences within the person and in interaction with the others.
- Facilitating environments that unconditionally support purposeful and playful learning.
- Adopting attitudes that encourage openness to all experiences and activities (social, ethical, and nonstructural).

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Chapter 15
The Paradox of Serious Fun

Anthony E. Middlebrooks

Abstract The chapter examines the concept of fun, specifically the contradiction that "serious" learning and positive affect, the fancy way of saying fun, are incompatible in and around the classroom. Despite the fact that pedagogies considered fun are often unique, highly interactive, and impactful; the fun descriptor is perceived as a badge of levity, thus limiting the useful application of otherwise effective educational approaches. This is a particular problem for those trying to help students develop their creative thinking identity and capacity, as well as those utilizing creativity to enhance learning. Lessons are drawn from research and practice on fun in work and educational settings, and numerous guidelines are provided for facilitating serious fun.

15.1 Why Can't We Be Fun?

Are you laughing? Then you can't be serious. There is a general belief that "serious" learning and positive affect, the fancy way of saying fun, are incompatible in and around the classroom, work setting, or any other serious goal-oriented setting. This even despite the fact that pedagogies considered fun are often unique, highly interactive, and impactful. The fun descriptor is perceived as a badge of levity, thus limiting the useful application of otherwise effective educational approaches. This is a particular problem for those with a sense of humor…and those trying to use creativity to enhance learning, and help students develop their creative thinking identity and capacity.

Many excellent resources for developing creativity have been created and tested. The basic premise of this chapter vis-a-vis creativity is that fun, in the most intuitive sense, enhances the potential for creative behavior. Fun runs through nearly all of Sternberg and William's (1996) 25 steps that promote classroom creativity. In many cases fun is a direct facilitating condition (e.g., tolerating ambiguity, encouraging

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sensible risks, imagining other viewpoints), while fun also serves as a personal, social, emotional, and/or contextual enhancement.

Let's start this chapter on serious fun with some serious fun. Think back on your educational experience – perhaps the elementary years. You'd probably describe the most fun facets of your early years, as most kids do today, as recess, lunch, gym, and perhaps art or music class. If you said math or social studies you either had an exceptionally different kind of teacher or you're an academic, which in either case is an exception. In any case, pick a favorite time and topic from your educational past. Now, see if you can describe it in pretend words that really capture the full essence of the experience – like amazzzzingy, wowowee, or smilish. Go ahead, take a minute, this chapter will wait for you… Ok, so it was probably fun to reminisce and make up silly words. Great! More important, why was the experience fun? What felt uncomfortable about encountering this kind of introduction in an academic text? Did it seem too frivolous? Was it too far out of the norm?

This chapter examines the paradoxical relationship we have with fun, particularly in settings that contain some kind of performance outcome and/or expectation – schools, work, maybe even family at times. Starting with the end in mind, here's the BIG message: Fun is an incredibly powerful phenomenon that we consistently fail to capitalize on because it's…well…too fun. Too fun, and by implication, not serious. Yet fun has quite serious foundations in our emotions and psyche, so much so that it allowed you to retain as impressionable what might be quite distant memories of your school days. Fun has highly impactful outcomes on our "serious" performance goals.

We all know the serious goals of life…and fun isn't one of them (until perhaps one reaches a certain age or state of enlightenment – anyone else with a goal of "fun" is not looked upon favorably). One important proviso to note: Fun does not equal crazy, wacky, all-out nonsense. Certainly for some, but in studies of attitudes toward fun, the 'wild and wacky' games were actually considered least fun (Karl, Peluchette, Hall, & Harland, 2005). Engaging and experiencing fun requires a degree of vulnerability – a psychosocial and emotional risk. Thus, Karl, et al.'s work (and others') suggests that trust is a key condition for fun. This can be contrasted with the well-known FISH! Philosophy that tempers wacky with support and trust (Ramsey, 2001).

The FISH! Philosophy profiles the Pike Place Market in Seattle, Washington, highlighting four core values that promote a highly engaged (and engaging) culture (Christensen & Charthouse International Learning Corporation, 2002). One of their core tenets, *Play*, is characterized by the employees throwing actual (dead) fish to one another as part of the sales process, as well as generally goofing around with customers. While the entire scene is full of almost hyper energy, a closer look reveals moments where employees effectively "read" the customer and deliver a moment of one-on-one serious connection that makes the fun serious, caring, and accessible.

The potential role of fun can more readily be seen where it is not utilized, namely by educator complaints: My students are disengaged, and they don't seem to care about the content, all they want to do is socialize and goof around, they have no motivation for learning, and consequently ignore the serious things that we educators know will help them succeed. Intuitively, and based on research, we know that fun can help address these complaints. But somehow it doesn't seem right – fun is just too fun.

15.2 Fun Matters

Fun can be a noun (feeling of enjoyment or pleasure), an adjective ("That was a fun activity!"), or even a verb if you think 'funning' is a word. Most often we think of fun as the personal feeling or mood resulting from our interaction with something, even if it is the abstract interaction with a memory or thought. Closely related, and often used interchangeably, are the two jesters causing all this fun: Humor and play. Humor and play bring their own extensive lines of research across multiple domains. However, it is helpful to note that when considering the contradiction of serious fun in practice, humor and play are the objects of frowned-upon frivolity. In other words, the 'serious' would be perfectly fine with you *feeling* fun as long as you are engaged in serious work.

From psychology, fun is an element of personality, specifically the fun-seeking disposition of Carver and White's (1994) behavioral inhibition system-behavioral approach systems (BIS-BAS) theory. For the practitioner, this theory frames human behavior as navigating the balance between activities that activate behavior and those that inhibit. Fun-seeking comprises a behavioral *approach* mechanism, implying that it is not so far from achievement as we might think. Yet even the BAS theory contrasts *Fun Seeking* with *Drive*.

15.2.1 Fun and Work

Paradoxically, much of the effort to examine fun has been done in the context of work, i.e., what does fun look like, how is it beneficial, and how can fun be incorporated into work – always with the caveat that it benefit the serious work. Karl, Peluchette, and Harland's (2007) model of fun at work focuses on the *attitudes toward* and *the experience of* fun. Other approaches describe fun as *activity* or *environment*. Workplace fun is, "…playful, social, interpersonal, recreational or task activities intended to provide amusement, enjoyment, or pleasure." (Lamm & Meeks, 2009, p 614) And, workplace fun is: "A fun work environment intentionally encourages, initiates, and supports a variety of enjoyable and pleasurable activities that positively impact the attitude and productivity of individuals and groups." (Ford, McLaughlin, & Newstrom, 2003, p 22).

Not all workplace fun looks the same. In the framework of humor, Stromberg and Karlsson (2009) lay out a continuum of humor from pure amusement to humor with a serious point, noting that fun and humor exist organically in organizations whether organized by management or not. More recently, Plester, Cooper-Thomas, and Winquist (2015) examine three kinds of fun, "…organic, which emerges from employees; managed, which stems from managers; and task, which results from an interaction of employees with the tasks they are assigned." (p 381) They note that these forms of fun often are happening at the same time, leading to underlying tensions in how different individuals perceive fun and how they reconcile those notions between each other.

With perhaps a few exceptions, we all would prefer a state of fun. But let's pretend for a moment that you are the boss, leader, teacher, parent, or person who has to answer to self and others regarding performance. How can you possibly justify fun as a strategy for achievement? Well, here is a quick list of the benefits of fun:

- Increases engagement
- Increases job satisfaction
- Increases task performance
- Increases organizational citizenship behavior
- Increases competence
- Increases trust
- Reduces anxiety
- Reduces emotional exhaustion

(Fluegge-Woolf, 2014; Karl et al., 2005; Karl, Peluchette, & Harland, 2007; Lamm & Meeks, 2009).

To sum, fun can be a personality component, a personal feeling, an activity, an environment, and/or an attitude. We know that fun comes in a range of forms. And, we know that there are considerable benefits to incorporating fun, as well as some detriments to not doing so.

15.2.2 Fun and Learning

If you have managed to read all the way to this chapter, you have also likely done pretty well in school. From the vantage point of the learned, incorporating fun into education seems like it should be a pretty fun-duh-mental. Indeed, a stream of studies illustrates the many benefits of fun (and its cousins – play and humor) to the classroom (Browne, 2013; Gorham & Christophel, 1990; McCarthy & Anderson, 2000; and Tews, Jackson, Ramsay, & Michel, 2015, just to name a few across various fields of study and practice). As Tews, et al., (2015) note, "The fundamental belief is that greater knowledge and skill acquisition will result when learners have more fun, are actively involved, and enjoy the learning process." (p 16)

An interesting study by Van Winkle (2014) examined the impact of fun on learning in a "free-choice learning setting" in which there are many learning opportunities yet the environment is not formal education, i.e., museums, historic sites, zoo, etc. Results indicated that participants found fun to have a lesser cognitive load, meaning students perceived the information as less demanding and difficult (and thus more understandable and easier to engage). The more fun the experience, the more it was perceived that something valuable was learned. The perception of fun was positively correlated to both transfer and perceived learning. Although not causal, this study reinforces our own experiences that visits to these places are more engaging and memorable relative to how much fun the experience offers.

The instructor may be the key to whether fun works or not. Building off of research showing the value of fun in the classroom, Tews et al. (2015) developed a scale to assess fun in the classroom. Their work divides fun into two major categories: fun activity and fun delivery. "Fun activities reflect a variety of hands-on exercises and ways to promote social involvement," (p 24) while fun delivery focuses on the instructor and his or her style of interaction. Their work suggests that fun delivery is more impactful to student engagement than fun activity. Robinson and Kakela (2006) alluded to this outcome in their work, suggesting that the instructor's work in, "…creating a space for fun, interaction, and trust, teachers and students can build a learning environment that promotes engagement, deep learning, and meaning." (p 202) "Teaching is an intensely personal activity and in many ways much like nursing – you deliver it from within 'yourself'; by using the skills you have as a person, be they extraversion and dynamism or gentleness and ability to hear others," note Baid and Lambert (2010) in their examination of fun activities in nursing education (p 551).

15.3 Connecting Fun and Creativity

Much of the connection between fun and creativity comes from anecdotes of initiatives that some rogue manager or educator tried out in an effort to do something different, wake people up, or spark engagement. Although not empirical research, these kind of stories matter – they are evidence that there is a perceived connection between fun, creativity, and some important outcome for individuals and organizations. Generally these stories go something like this: Our group was not performing/not happy/not engaged, and so we thought, "What the heck, let's try to have some fun!" We played this game/held this contest/put on this event, and (surprise, surprise) people reengaged, reconnected, reenergized, and produced more and creative things! A good example of this can be found in Kumar and Raghavendran's (2014) article *Bringing Fun and Creativity to Work*, where they introduced a team-based contest into Deloitte, LLP's India operations. It is not clear that there was any empirical work that informed their project, yet their assessment from participants indicated "extremely positive impact on the Deloitte culture." (p 95)

One essential pre-condition of fun, and funny, is the juxtaposition of very different or opposing ideas – an incongruity. For example, using a clothespin to fasten objects together is not funny…it's what a clothespin is generally supposed to do. But to consider 'fun' uses of a clothespin would require moving outside the expected, like to clip your nose shut while swimming, or envisioning behind the scenes gods pinning clouds together, or even further where the giant clothespin is a new gymnastics event, or further still as angry clothespins descend from a spaceship to take control of appliance stores. Utilizing fun to consider very different perspectives inevitably encourages creativity and new ideas. Dekker and Teule (2012) highlight this notion in their analysis of the growing use of fun in economics (yes…you read that correctly).

How one frames a task also seems to influence the types of thinking individuals utilize. Framing a task as fun necessarily lowers performance expectations, and with that also lowers stress and anxiety, and broadens focus. Friedman, Forster, and Denzler (2007) found that a task framed as fun resulted in better performance on the alternative uses task. Similarly, Barsoux (1996) explains how humor reframes the introduction of new ideas as low-risk, and encourages divergent thinking by loosening the constraints of logic and serious discussion. Humor has been linked to creativity across many studies, primarily focusing on the role of humor in setting a tone of openness, playfulness, and positive affect (see Romero & Cruthirds, 2006, for a nice overview of humor in the work setting).

Fun and creativity can also be considered at the group or team level. A culture of fun, which will be discussed later in the chapter, wields a powerful social influence on expectations, activities, feelings, and aspirations. The greater the group cohesion, the stronger these influences will be. Fun and humor facilitates group cohesion by, "…clos(ing) the communication gap between leader and followers, making organizational confusion more bearable, drawing attention to areas in need of managerial attention, facilitating change and encouraging plurality of vision. In short, it helps to break down barriers between people and make an organization more participative and responsive." (Barsoux, 1996, p 507) The consequent increases to organizational citizenship behavior may result in greater creativity as strong team identification is positively related to creative effort (Hirst, van Dick, & van Knippenberg, 2009).

15.4 What's the Hold-Up? Blocking Fun…and Creativity…and Learning

We love to have fun, and we know how to have it – at home, at school, and at work. We know how to have shared fun and find mutual fun, even across generations (Lamm & Meeks, 2009). We know the great benefits of fun, both intuitively and from research. With fun, we are more engaged, satisfied, competent, and creative; we are less anxious, stressed, emotionally exhausted, and afraid of risk and ambiguity. So, why are we so reluctant to introduce and utilize fun when we deem a task as serious?

The big hold-up to capitalizing on the power of fun sits on your shoulders (yes, that refers to your head). The brain constructs our perception of the world and all that is in it through the many interactions we have with the world –direct interactions, social interactions, observation, and reflection. The best way to visualize this

Table 15.1 Student's misconceptions about learning

Things are black and white – Students conceptualize activity and content in terms of black and white – dichotomous and incompatible – work versus play, serious versus fun, productive activity versus frivolous.
Learning is acquiring – Students conceptualize learning as acquisition of information and only a cognitive endeavor, when we know that acquisition is just the very first step in learning, just as cognition is one of many facets of understanding.
Learning is not fun – Students see fun as completely disconnected from learning, and associate 'not fun' feelings with learning.
School is lecture by experts – Students have a traditional concept of education, which is generally the lecture-based, 'sit and get' model. The more strongly embedded this concept, the more uncomfortable students are with any variation in pedagogy.
Serious is not playful – Students conceptualize 'work' similarly. As Tim Brown (2008) notes in his TED Talk on creativity and play, "…it's very easy to fall into the trap that these states are absolute. You're either playful, or you're serious, and you can't be both. But that's not really true. You can be a serious professional adult, and, at times, be playful."
I am limited – Students underestimate both their capacity for learning and the amount of engagement required to fully understand.

notion is with the phrase: Your brain is a lean, mean, pattern-making machine (credit to Dr. Michael Dickmann from Cardinal Stritch University). Once constructed, these conceptualizations inform your perceptions. In other words, how you think about the world is how you see the world. This now common understanding of the constructive nature of the brain bears repeating. Your brain craves organization, so much so that even when confronted with randomness, we struggle to make up connections and relationships. How you think about the world – your construction – determines how and what you see in the world. If your mental construction of children is little brats who cause trouble, then the only things you *see* in children are those potentially trouble-making behaviors. This phenomenon informs both your perception and your consequent behaviors. This is no different regarding fun – one's attitude toward fun affects the degree to which one experiences fun (Young, Kwon, & Kim, 2013).

"A group has a culture when it has enough shared history to have formed a set of basic assumptions which guide behaviour, perceptions, thoughts and feelings" (Schein, 2004, p 21). The educational culture we have created has left students with a number of misconceptions that block their use of fun as a learning tool. Obviously this is not the case for all students, all classrooms, or all the time; but these misconceptions are prevalent, consequential, and in need of further research to more fully understand and address. Table 15.1 summarizes some of the most common misconceptions students maintain. Which ones look familiar? More important, in what ways could you help students see beyond these constructed ideas?

Just as students are filled with misconceptions about fun and learning, their ideas about creativity are even more troubling. Blocks in creativity are well-documented, and include much more than the conceptual. Creativity blocks can be emotional, social, and cultural (Adams, 1986). Even serious fun cannot foster creativity in the

Table 15.2 Common creativity blocks for students

I must be artistic, witty, or I am not creative – Conceptually, students believe creativity is generally related to artistic talent or to witty personalities, both of which you either have or you don't. So it follows that if you are not creative, no amount of fun in the world will change that.
I must find the answer! – As creative problem-solvers students tend to be satisficers – whatever idea arises that seems to satisfy the problem will suffice (versus generating many ideas and choosing the best one).
Only "good" answers count. – The habitual process of 'finding the answer' has been deeply ingrained such that students self-edit and squelch their own creative process (see Davis, 1986 for a great list of squelching statements). When asked to generate ideas students struggle to produce what they perceive as a quality or creative idea, rather than generating a quantity of ideas.
I really don't explore. – Students limit the range of creative possibilities – limiting their perspective to theirs and those around them, limiting ideas to their field or related fields, and not considering radically different contexts for idea possibilities.
I am too busy to be creative. – Contextually, students stifle their creative potential by being overbooked, overcommitted, overanxious, and when they have any sliver of daylight to think, they fill it with social media or other online adventures.
I am (still) limited. – Students underestimate their capability and capacity to be creative. Many believe that they simply are not creative because their false concept of creativity. Every semester students surprise themselves with their divergent thinking ability…but only when pushed, and then pushed more.

face of blocks. Right at the top of the blocks list is the assumption (or even declaration) that we like and want creativity! "It's all a lie," writes Jessica Olien (2013). "This is the thing about creativity that is rarely acknowledged: Most people don't actually like it. Studies confirm what many creative people have suspected all along: People are biased against creative thinking, despite all of their insistence otherwise." Questioning our basic assumptions about creativity and fun, particularly in a context where we are leading a serious task, is a necessary first step. Table 15.2 summarizes many of the most common blocks students apply to themselves.

Finally, you cannot have fun if you're hungry – or tired, scared, insecure, afraid, or lacking any number of foundational needs. Looking at the relationship between well-being and fun, Baptiste (2009) describes well-being perspectives vis-à-vis fun from in-depth interviews of local government senior managers, noting that, "… experiences of well-being at work are strongly associated with material aspects of employment relations which have to be addressed before the philosophy of 'fun at work' can have meaning or relevance." (p 609) These concerns include issues of work-life balance, stress, relationship with management, and safety.

The perceived limitations to creative activity and engagement that comprise a student's way of seeing themselves and the world ultimately stifles their potential. This conception is a product of experience – the way we do things around here, and countless interactions with those teachers (and parents, mentors, leaders, etc.) after whom students model what serious achievement entails. Unfortunately, those students then become the teachers, modeling and passing on this cultural and conceptual blockade to the next generation.

For one full semester of teaching research methods to doctoral students I responded to numerous questions with the response, “It depends.” On the last day of the semester, for the holidays, the students brought me a very large, festively wrapped gift. My delight was soon shifted to wry amusement when upon opening it I found a large box of Depends – undergarments that serve an important purpose, but not quite yet for me, and certainly not the gift I was expecting. From that semester on, every question was met with a new response: “Well, that is the million-dollar question!” I have yet to receive that gift. But, the million-dollar question for this chapter is: How can we reconcile the ‘serious’ necessary for learning and achievement with the ‘fun’ that actually enhances those ends?

15.5 Rules of (Serious) Fun (Seriously)

Unless you’ve recently seen some post-apocalyptic zombie movie, “no rules” seems like it would be fun – unless, of course, your idea of fun is not on the menu. Unlimited chaos turns out to be not so fun, nor productive (Hill, Brandeau, Truelove, & Lineback, 2014). And, this fun-equals-chaos fallacy is the greatest fear of those who are in a position of leadership…like teachers. Fun, oddly, requires rules – to clarify goals and norms, to focus activity, to ensure psycho/social/emotional safety – essentially to set the parameters within which individuals can play.

Designer Tim Brown (2008) discusses the idea of play as a means of better understanding problems and generating ideas. Brown highlights exploratory play, role play, and playful building, each of which require a set of rules to participate. For example, a role playing activity does not work (nor is it fun) if you are playing a role and others are not, or others are playing a different storyline, or a different story altogether. As Brown notes, “When kids play tea party, or they play cops and robbers, they’re following a script that they’ve agreed to. And it’s this code negotiation that leads to productive play.”

In the work setting, Plester (2009) discusses the importance of workplace boundaries, asserting that they both enable and constrain workplace fun in such a way that fits with culture and encourages harmony. “Formality and fun can coexist,” notes Plester (p 593), but only when the boundaries are clearly communicated either through the culture or, failing that, through managers or employees. Clear boundaries also provide parameters for defiance, edginess, and challenge, which some speculate enhances fun (Carver, 2013). What happens when the boundaries between work and fun are blurred? Fleming (2005) conducted an 8-month field study of an organization known for their culture of fun. Surprising even to the researchers, the study turned out to be a fascinating look at how *not* to integrate fun. The activities and interactions imposed by managers were perceived as juvenile, condescending, and inauthentic, resulting in employee cynicism. Definitely not fun.

The rules for effective, serious fun will certainly vary by persons and context. With that variability in mind, what follows are a number of ‘rules’ from which leaders and educators could draw to facilitate serious fun. The first four rules comprise the “Laws of Fun" as established by The Fun Dept, a company who's mission is: "To create opportunities for people to have fun at work" (Measley & Gianoulis, 2015, p vii). "Fun (at least workplace fun) is not about hopping on one foot blindfolded, wearing embarrassing costumes, or forcing employees to be silly. Fun at work is building solidarity, connection, and an outlet for workplace stress," they note in their book *Playing it Forward* (p 5). The challenge posed in this chapter – reconciling and facilitating serious fun – comprises much of what The Fun Dept has wrestled with over their years of developing and delivering fun. While their primary focus has been the work setting, their insights are easily transferable to the educational setting.

And so, without further delay, the ten rules of serious fun:

Rule 1: Fun requires leadership buy-in and participation.

"It all starts at the top," notes The Fun Dept. (p 8):

> If leadership isn't leading the charge, employees will hesitate to engage, and that will undermine the initiative from before the first fun idea leaves the planning group and makes its way into the office. Leaders launch the fun; informing employees not only that it's OK to have fun, but that they are going to be right there with them. When it comes to fun – or any major organizational initiative, leadership support is key to success and impact. (p 9)

Support is critical, but it is not enough. Leaders model the cultural norms, and if fun is an acceptable part of work, authentic participation by leaders communicates that priority. "You do not need to be the center of attention. You just need to be present, both physical and emotionally." (p 15) This notion is further reinforced in the educational setting. Tews', et al. (2015) found that instructor-focused fun delivery is more related to student engagement than fun activity: "Based on these findings, one can conclude that students particularly value instructor-centered fun…" (p 24).

Rule 2: Fun is a shared experience – and needs to include leadership buy-in.

Fun is highly subjective, and yet facilitating serious fun in education or work settings means finding the fun that works for all. The Fun Dept runs an exercise with groups to help find that shared fun. The exercise starts with individuals generating a list of what each person does for fun or considers fun. Facilitators then ask individuals to compare lists in overlapping Venn diagrams, looking for obvious mutual interests or creating unique connections. The process continues until all individuals have connected. At first glance this exercise appears helpful but unworkable beyond a very small group. Expanding this to a larger group is where the creative reconceptualization of "a fun activity" emerges. As The Fun Dept explains in an example:

> We asked two volunteers to jot down their lists, share their interest with the class, and hopefully uncover that 'x' (indicating a mutual interest).
>
> Indeed, the two volunteers had one thing in common: cliff diving. That's right. Cliff diving.
>
> We asked the other 48 students, "Who would NOT want to go cliff diving"? At least 20 students raised their hands. Then, we asked, "If we still chose a cliff-diving activity, like a competition, how would you want to participate?" Our goal was to find middle ground (for those who preferred staying on the ground). The 20 students came up with great ideas:
>
> 1. We can be the judges, scoring the dives from 1 to 10.
> 2. We can be in charge of the food.

3. We can take pictures and short videos and post them on social media.

One student said, "I'm a DJ. We can bring music and make introductions. As long as I'm not cliff diving, I'm happy!" (p 34–35).

Reinforcing the idea that fun must be shared and mutual, perhaps an interesting sub-rule for fun may lie in team membership. In fact, Hirst et al. (2009) suggest that "identity based regulation" might serve as a precursor to creative behavior.

Rule 3: The 3C's: Consistency, company time, culture compliance.

The three components of this Fun Dept rule focus on the implementing fun in an organization. They explain consistency as, "When it comes to fun in the workplace, consistency is key. Fun should feel as natural and typical to the staff as the morning commute, coffee break, lunch, afternoon stretch, happy hour, and commute back home…Fun is like exercise. Stick to a consistent regimen, and you'll enjoy long-lasting results." (p 37)

Regarding company time: "…company leaders hesitate to schedule fun events on company time. Doing so, they believe, impacts productivity and is merely a distraction. Often, plans are made to usurp valuable down-time for employee engagement with events scheduled during evening hours or weekend. Work is stressful enough…fun can take less than 15 min. And it should!" (p 39) The equivalent in education would be cutting into recess and lunch!

Finally, culture compliant refers to the subjectivity of both individual and group. "Compliant fun will: Integrate with your company's culture and encourage everyone to participate – in their own way. First, make sure you have a good sense of the likes, dislikes, tolerances, and intolerances of the folks who make up your organization. Remember the Venn diagram we drew earlier?" they explain, "Second, fun needs to appeal to extroverts and introverts alike. Some employees will gladly do the limbo; others will prefer watching." (p 41)

The Fun Dept provides the following chart to help explain how these three components go into making BIG FUN:

	Consistent	Company time	Compliant	Challenges
BIG FUN	√	√	√	The company should regularly update its list of fun ideas
More Fun	√	√	X	Less trust in leadership and risk of employees getting in trouble.
	√	X	√	Compromised work time or personal time.
	X	√	√	Uncertainty as fun is not part of the cultural fabric.
Some Fun	√	X	X	Disconnect between the fun at work and the company's culture.
	X	√	X	Disjointed waste of work time.
	X	X	√	Disjointed waste of personal time.
No Fun	X	X	X	Total disregard for the entire workforce.

Rule 4: Fun for all the senses.

The experience of fun is primarily emotional. "Fun should strike an emotional chord by tantalizing all the senses. It should look good, sound good, feel good, smell good, and taste good." (p 48) As any educator will attest, excellent pedagogical design will strive to maximize the sensory input, and thus maximize the connections with the content.

Rule 5: Fun comes in many flavors.

In addition to being highly subjective, as well as an often shared and dynamic experience, fun takes on many forms. Winter (2011) created a taxonomy of 21 types of fun, including Fellowship, Altruism, Discovery, Challenge, Danger, and Reflection among them. Understanding the broad range of fun enables leaders to better identify what followers find fun, and offers an array of options to suit the individuals, task, context, and moment.

Rule 6: The sources of fun are broad and endless.

Each type of fun can be executed from a variety of sources, offering those planning and facilitating fun a great many options. The most impactful source of fun is other people. Shared fun is contagious, and often what is slightly amusing to the individual becomes uproariously memorable when shared with others. Leaders must create unique ways to group individuals and encourage interaction. Other sources of fun include objects, places, novelty, the unexpected, and even one's own mind and past memories.

Rule 7: Forced fun, isn't.

Autonomous, emergent, organic, open, self-directed – all terms related to the contextual feelings that speak to delicate encouragement…and require the trust noted earlier. You cannot force fun. Period.

Rule 8: Know what is NOT fun (and what is not funny).

Awareness of what is not fun is as important as determining what is perceived as fun. "Not fun" has great power to thwart the activity, stall a group, and erode a leader's credibility. This rule goes along with the notion of The Fun Dept's culture compliant idea and can serve as a critical facilitation tool. Plester (2016) provides an excellent overview of the dangers of not fun, noting, "…fun, though enjoyable, is not necessarily funny – thus fun does not necessarily incorporate humour, although humour does often occur during fun activities. This contrasts with the complexity of humour and although it can be light-hearted, humour can also have a dark side…" (p 5).

Rule 9: Facilitating serious fun is a balancing act.

Awareness of mental constructs and blocks, strategies to overcome those blocks, and activities to develop creative and fun dispositions are foundational. However, the real genius of facilitating fun rests with the leader's ability to balance the competing paradoxical actions and goals with a given person or group, on a given task, in a given context. The six paradoxes of leading innovation suggested by Hill et al. (2014) are an excellent start to identifying and tracking these balances. The paradoxes are presented as scales with degrees of emphasis rather than either-or. These paradoxes include: (a) honor individual identity versus encouraging collective identity, (b) encourage support between peers versus confrontation, (c) emphasizing learning and development versus performance, (d) allowing improvisation versus imposing structure, (e) expressing patience versus urgency, and (f) encouraging bottom-up initiatives versus top-down projects.

Paradoxical thinking may be the most valuable guideline for those facilitating serious fun. Effective execution requires awareness of and ability to balance these competing tensions. One could add the balance between organic, managed, and task-driven fun (Plester, Cooper-Thomas, & Winquist, 2015) as well as Brown's consideration of when to play: "Kids don't play all the time… They transition in and out of it. …good teachers spend a lot of time thinking about how to move kids through these experiences."

There you have it – ten rules of serious fun! Wait…what about rule 10?! Oh, right, rule #10 of serious fun: Surprise individuals by ending the day earlier than they expect. Everyone enjoys recess!

15.5.1 From Myth to Practice – Go Get Yourself Some Fun!

Incorporating fun seems to be gaining traction as a necessary component of leading, managing, and educating – resulting in positive contributions to multiple bottom lines (Bolton & Houlihan, 2009). Fun done right offers amazing possibilities for enhancing teaching, leading, and creativity. It offers a plane of mutual understanding and enjoyment, social and emotional connection, and the promise of finding the balance between personal joy and achievement.

"At the core of innovation," and for the purpose of this chapter, creativity, "… lies a fundamental tension, or paradox, inherent in the leader's role: Leaders need to unleash individual's talents, yet also harness all those diverse talents to yield a useful and cohesive result" (Hill et al., 2014). This chapter sought to unpack the concept of fun as a vehicle to reconcile that tension. If you are not yet convinced, The Fun Dept debunks six of the most common myths around utilizing fun:

Myth #1: Creating fun is expensive and time-consuming.
Wrong! – Fun can be cost-effective, brief, and well-designed…delivered to small groups over time. And there are many, many sources of great ideas for generating fun in big and little ways (e.g., see Jonas, 2010 for numerous practical suggestions applied to the educational setting).

Myth #2: Fun is frivolous.
Wrong! – Companies lose over $2000 on average per disengaged employee per year. What is the 'cost of a disengaged student?

Myth #3: Employees don't want to make fools of themselves; they won't want to participate.
Wrong! – Through deliberate planning, and with experience, trust and optimism will win the day. Leahmann-Willenbrock and Allen (2014) found that under conditions of job security, humor related to team performance sparked positive communication and solution finding. However, under conditions of job insecurity, those positive effects were not present.

Myth #4: I don't want to deal with the office politics that might crop up.
Wrong! – Turns out that fun programs, when done right – actually serve to bond your staff together. Office politics and drama take a back seat to fun.

Myth #5: I am not sure I know how to create fun that my staff will enjoy.
Wrong! – There are many, many techniques for generating hundreds of ideas for employee engagement and fun programs!

Myth #6: I don't feel comfortable promoting fun (and I don't feel like I'm the most fun person, either).
Wrong! – Relating to your staff, employees or workforce (or students) isn't always a natural or innate talent, that's true. Leadership in employee engagement begins with taking responsibility for the uptick in morale, productivity, and creativity. (p 9–12)

Without engagement, there is little learning. One of my earliest challenges in working with children was how to get them engaged in activities with which they were unfamiliar, i.e., try new things. We would explain how fun a new game was, show them all the cool parts, model authentic excitement, try to convince them that they'd enjoy it, frame it as a challenge or a mystery, offer prizes, and a host of other strategies. Some worked, some of the time, to some degree. But by far the most effective approach was to simply sit down, without saying a word, and start to play. "What are you doing?" came the inevitable inquiry. "Playing a new game," was the vague response. "What's it about?" they pressed. "Oh, I'm trying to (objective)." And from there the student drew themselves into the challenge…and fun…and learning. And within the context of the activity, their creative problem-solving brains kicked into gear in a reciprocally reinforcing relationship with fun. I have never seen anything taken more seriously than kids having fun as they immerse in an activity.

The paradox of serious fun is actually not such a paradox after all. In order for students to authentically experience fun, there needs to be a degree of serious reality. "The meaning makes it fun," summarizes Schaller (2011) in his article highlighting game-based learning in museums. And, the fun makes it meaningful.

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Chapter 16
Creativity in Music Education? The Wild Card That Got Stuck in the Deck

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Abstract Working within the field of creativity can be difficult within a context of the arts. Just mentioning the word could get you into trouble. One thought is that in arts education we don't talk about creativity in fear of loosing the "magic" about it. The arts are per se a creative context so why bother defining it, describing it, or even researching it? It just is. In this chapter, I discuss this tension and provide examples of work that gives creativity a voice in Music Teacher Education.

16.1 Introduction: Creativities Transcending Boundaries in Higher Music Education

If I could have a penny for each time some one made the following remark: "Oh, you work in higher arts education. That must be a creative place!" I would be an extremely rich person. Most people hold the idea that music by itself is a creative art form and by teaching it or performing it you are automatically a creative person. To this remark I always answer "of course" knowing that it all has to do with perspective and perception (and perhaps a limited assumption). In a mini-survey, conducted in 2010, scanning through all the curriculums at Lund University searching for the word creativity in a 10-year period, the word had completely dried out within the Faculty of Fine and Performing Arts and exploded like a tsunami wave at other faculties within the university. Does this mean that creativity does not exist within higher arts education? Of course not. Perhaps we use another word, perhaps it is intertwined in the context and doesn't sit "in the walls", as a colleague of mine put it, but rather carried out as a verb, an action, through the daily work. Or perhaps the truth is that higher arts education isn't a more creative place than any other higher education. Or worse, perhaps arts education, living under the creative spell, is in fact a less creative place since we don't talk about it because then it will lose all its magic?

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Five years ago my colleague, Eva Sæther, and me had the opportunity to further understand the link between creativity and higher arts education pedagogy through the perceptions and opinions of students and teachers at Malmö Academy of Music (Houmann & Sæther, 2014). This research study aimed towards determining how experienced academic music teachers understand their role and the context of university in relation to fostering the creative capacity of their students and how the student perceived this. Going through literature on creativity inside and outside higher education, we searched for keywords that would help us with the visionary direction of our effort to include our students and colleagues in the process of enhancing creativities (that's right, plural) in higher music education. Eventually we focused on two fields of tension: the dual dichotomies of risk-comfort and joy-seriousness. We also wanted to include the collaborative and community aspects of creativity, leading to the pluralism of the concept, creativities.

Based on the condition that a project like this had to involve both students and teachers, we initiated a process that we hoped could impregnate the new teacher training in the coming years, and provide empirical material for research projects. This chapter tells the story about the project called "Creativities – Transcending Boundaries in Higher Music Education" and how it gave creativity a voice in Music Teacher Training.

The academic year 2011–2012 marked the start of a new music teacher education in Sweden – the third within a period of 10 years. The focal point at our academy was that "the music teachers whom we educate now will educate children and youngsters born around 2040, people who will retire in about 2105" (Houmann & Sæther, 2014, p. 174). What they will need during their professional careers is creativity. If students can use their creativity to combine their knowledge about pedagogical and psychological research with tried experience of music and learning to change their working methods and approaches then they can renew their teaching to create new creative learning environments for children and young people.

The nexus of creativity and higher education pedagogy has been brought to the fore by a growing interest in (a) understanding the precise nature of creativity, (b) asserting the link between creativity and economic productivity, (c) calling for a greater focus on creativity in higher education policy and (d) provocations about what precisely pedagogy for creativity capacity building might look like. In the "Creativities Transcending Boundaries" project we used a mix of quantitative methods and qualitative approaches, such as involving both students and teachers in workshops to discuss and reflect on the different approaches to creativity that were brought to the surface by e-mail surveys. The survey was a modified version of the "UK Higher Education Academy: Imaginative Curriculum" report 2 (The Creativity Centre, 2006) and an extended version made at the Carrick Institute for Learning and Teaching in Higher Education in Australia (McWilliam & Dawson, 2008). Although the aim of the study was not to compare Swedish teachers and students to the British and Australian results it is to some extent interesting to note differences and similarities when it comes to perceptions of creativity. In our study 53 students and 36 teachers answered the questionnaire and 100 students and 80 teachers took part in the following workshops where the results were discussed. The aim of the

Table 16.1 First and second generation creativity concepts

First generation creativity concepts	Second generation concepts
Serendipitous, non-economic	"Hard" and an economic driver
Singularisation	Pluralized/team-based
Spontaneous/arising from the inner self	Dispositional and environmental
Outside the box or any other metric	Requires rules and boundaries
Arts-based	Transdisciplinary
Something out of nothing	Something to something else
Natural or innate	Learnable
Not amenable to teaching	Teachable
Not assessable	Assessable

McWilliam and Dawson (2008)

workshop was to invite all involved to participate in future development of the project and to continue to reflect on their own attitudes to and skills in creativity in music education.

16.1.1 The Complexity of First and Second Perceptions of Creativity

One reason for the silence on creativity in higher music education could be the different perceptions of creativity. McWilliams and Dawson (2008) introduce the first and second generation concepts of creativity (Table 16.1).

"First generation" thinking about the nature of creativity can be characterized as focusing on "soft" creativity, i.e., creativity as giftedness so mysterious and serendipitous that it defies definition, or, as Claxton (2006) stated: "a rare exotic mental ability that stands apart from normal cognition" (p. 59). A corollary of this perception is that creativity also defies any attempt to foster is systematically through formal learning. According to McWilliams and Dawson (2008) such perception of creativity is relevant to a small percentage of graduates (overwhelmingly in the performing and visual arts) as future professional workers.

Recent research has challenged these propositions as myths, compiling evidence to support "second generation" thinking about creativity as a workplace capacity that is an observable and valuable component of social and economic enterprise (Cunningham, 2005, 2006; Haring-Smith, 2006). Put in Csikszentmihalyi's (2006) terms, creativity is no longer a "luxury for the few, but…a necessity for all" (p. xviii).

Key learning theorists have provided second generation scholarship with a platform for arguing that three components of creativity –domain relevant skills, creative processes, and intrinsic task motivation – can be identified and fostered through formal and informal learning (Folkestad, 2006; Robinson, 2000; Simonton, 2000;

Sternberg, 2007). There is some consensus around the view that creativity works as both a way of thinking "associated with intuition, inspiration, imagination, ingenuity and insight" and "a novel and appropriate response to an open-ended task" (Byron, 2007).

Second generation thinkers assert that sort of "hard" creativity that leads to innovative organizational practice is more likely to be an outcome of adaption – new recombinations of what currently exists (see Leadbeater, 1999; Lessig, 2005) – than of "flash-of-inspiration" moments or the radical invention of something out of nothing. Csikszentmihalyi (1999) makes an important addition to "second generation" definitional work, by insisting that it is the community, not the individual, that is the appropriate unit of analysis when seeking to inquire into creativity. This proposition challenges conceptions of creativity that are limited to personal psychological traits or the mystical "inner life" of individuals. This pluralisation of the unit of analysis of creativity raises substantial issues for higher education if graduate attributes continue to be understood and measured in predominantly individualized ways. It indicates that the student cohort or community of learners is the unit to which creative capacity may be more appropriately attributed, not the individual graduate.

This model of first and second generation perceptions of creativity also relates to discussions about talent and musicality. Is it a rare gift or can it be learned and developed? On a general level, our respondents held a mix of "first" and "second" generation ideas about creativity as a human capacity. On the one hand, respondents appear to endorse the first generation view that, in personal terms, creativity is an individual capacity that is best fostered by removal of any or all constraints. As one teacher put it: "I don't believe you can learn or teach how to be creative – it is something you already are. My job is to remove all constraints". On the other hand, there is recognition of the importance of group- or team-based approaches and of "direction", "processes" and "support" when fostering student creativity. Furthermore, they also reflect "first generation" thinking about creativity as best achieved through "arts-based" pedagogy, but also insist, in accordance with "second generation" thinking, that both science and the arts are fertile spaces for developing creative students capacity.

Koestler (1964) identified the decisive phase of creativity as the capacity to "perceive…a situation or event in two habitually associative contexts" (p. 95). Following Koestler, the capacity to select, reshuffle, combine, or synthesize already existing facts, ideas, faculties and skills in original ways can be taken as evidence of creativity at work. Perkins (1981) insist that skills like patterns recognition, creation of analogies and mental models, the ability to cross domains, exploration of alternatives, knowledge of schema for problem solving, fluency of thought and so on are all indicators of creativity as a set of learning dispositions or cognitive habits. These scholastics moves to unhook creativity from "artiness", individual genius and idiosyncrasy, and to render it economically valuable, team- or community-based, observable and learnable, shift the focus to creative ways of thinking and doing that are observable and replicable processes and practices within daily economic, social and educational life. Thus "second generation" thinking indicates that creativity can be engaged intentionally as an outcome of pedagogical work.

In our study the notion of creativity as "mysterious processes" was the lowest-ranked item for all sample populations: questionnaire and workshops. As mentioned above the participants perceptions reflected a mix of first and second generation thinking, with "hard" thinking and doing skills ranking highly, "seeing unusual connections", "innovation", "combining ideas" and "analytical thinking" being valued alongside "imagination", "invention" and "sudden inspiration". The majority of responses were related to the categories of thinking and doing. A notable exception in the study was the category "the arts". There were very few perceptions of creativity related to the arts. Although one respondent made reference to "the arts", the description provided was more aligned with the category "self-expression". It could be that the context of the study is higher music education so the connection between creativity stands to reason. Participants were requested to indicate their level of agreement with a series of statements relating to creativity and education. Firstly, we observed the level of agreement regarding the perception of creativity as a rare gift. In this instance, over 85.5 % of the students and 85 % of the teachers disagreed with the notion that creativity is a rare gift that only a few people have. The vast majority of participants were in agreement that creativity could be developed.

16.1.2 The Fields of Tension Deepens

Initially teachers were rather irritated by the questions put in the questionnaire and some were quite put off by being asked questions about creativity in this manner:

> Creativity is a necessary condition that cannot always be controlled. It depends on numerous factors which all needs to interact. It is interrelated to the interaction with other people.// I don't agree with the bias in the ingress of this questionnaire – creativity is not a goal by itself that can be reached with the help of fine art and music! Creativity can never be disconnected from the activity it is "used" in. Fine arts and music cannot be reduced to a cleaning lady for creativity. That is why so many questions are impossible for me to answer in addition to the quantification of the answers. I am looking forward to the conversation that can take place at the Academy and that already are. (Teacher X)

This quote also relates to who puts the question about creativity. Through some of the teachers' descriptions it is clear that there is a field of tension between researchers and practitians. There seems to be an understanding that creativity can't truly be understood by anyone else but the persons involved in the daily work. Many things can explain this but perhaps the concepts of tacit knowledge (Polanyi, 1966), knowing in action (Schön, 1987) or implicit knowledge (Chomsky, 1965) can be of help. A significant part of professionalism lies within the repertoire of action patterns that have become automatized by frequently repetition in praxis. This ability to perceive and handle situations within the profession can from the perspective of the uninvited look rather magical. Actions are carried out on intuition, and the persons carrying them out cannot always explain what they are doing. Furthermore, if you perceive creativity from a perspective of first generation as giftedness, case is more or less closed. So who are you to ask? As Louis Armstrong said: "Man, if you have to ask what it [jazz] is, you'll never know." In some way this has created a discourse where its own occupants are the only ones that can do research within its field. To introduce the questionnaire in our study we wrote: "Welcome in to our mutual investigating, mapping and developing of creativity. We do it together – teachers, researchers and students!" As researchers and teachers at our own academy we, naïve as it might be, thought we were insiders, "within its field". Turns out we were outsiders trying to get in. Conversations was already taking place, we were just not invited.

During the later years the importance of writing and reflecting has been more and more emphasized in teacher training and also, of course, in music teacher training. A focal point in students writings and reflections, at our academy, is knowledge as a form of awareness (Molander, 1996), knowledge as action, lived knowledge, embodied knowledge in constant motion; changing between insight and distance, reaction and reflection, part and whole, trust and risk taking. Due to current evaluation systems universities are assessed on the students capability to write an independent project (degree project) and the quality of the same (The Higher Education Ordinance, Swedish Code of Statues, No. 1993:100). This has of course been debated and discussed over the years. At our academy it has foremost amplified the field of tension between the parts of teacher training suggested to be more artistic/practical and the parts that are described as scientific/theoretical and to some extent also put creativity in the center of the battlefield. Who can claim that word/phenomena/activity? Researchers or practitians? Interestingly one teacher made a comment in the questionnaire that we were to late researching creativity, they had already moved on to other words.

> I don't want to sound snotty, but I don't use this word anymore. I suggest you use generate, the ability to generate, instead. (Teacher X)

In sum, our study showed that the essence of creativity in higher arts education was a hard nut to crack. Not only in the way we were doing it but the fact the WE, as researchers, were doing it. Students that write their degree projects enters a discourse that reminds of a catch 22; to write about their coming profession or artistry, mainly consisting on tacit knowledge, they have to break the unbreakable spell in transcending the field of tension between artistic/practical and scientific/theoretical using creativity to cross its boundaries and in the end of the process this degree project will, in the eyes of the assessment model, be valued more than all the other artistic/practical efforts, abilities, accomplishments they have done during their 5 years of teacher training. We, as researchers, teachers and supervisors of the students' degree projects became symbols of Dantes inferno. Are you still wondering why we were not invited? Alas one teacher respondent wrote in a comment: "You are researchers, shouldn't you know all this already?"

Interestingly every student does a degree project, as mentioned, leaving their second cycle at the university but when it comes to artistic research and funding of such projects it is not a requirement to have a PhD to be able to apply to the Swedish Agency of Research as it is within all other fields of science. This implies that the field of tension, when it comes to tacit knowledge, goes beyond higher arts education, mum is the word.

This brings us to hybridity, a useful concept or a tool for playing with differences. Said (1999) explains hybridity with the help of a musical metaphor: a polyphonic work, where there is no leading melody and no following other parts, where all voices are of equal value. With the help of hybridity and the play with differences, it is possible to find new questions and to promote critical thinking. All very useful in educational settings, as a critical approach could be "the essence of all education" (Said, 1999, p. 266). Differences are important in this context too, since they offer possibilities for change. Change of attitudes, norms, curricula, teaching and research methods.

16.1.3 Creativity as a "Wildcard" in Academe

Most of the participants in the study perceived themselves to be creative. But we also got responses along the lines of: "I whish I were, it would be good for my work, my fellowmen and my life situation." When asked to justify why they perceived themselves to be creative, respondents related their understanding of creativity to thinking and problem-solving skills as well as to self-discipline and working together with students. In this context, the responses suggest that the concept of creativity is a skill or attribute that can be fostered and developed:

> I try of course, to be creative both in my musicianship and teaching by continuously analyzing my work. I do this in my musicianship by listening to my recordings of me playing, and as teacher by discussing the reflections of my teaching with friends and colleagues. A big help are the evaluations I do together with my students. Their fresh perspectives give a lot of ideas. (Teacher X)

While a minority indicated that they were not creative individuals, their responses suggested that a certain level of creativity had been learnt and developed through experience. For example: "Not particularly, but through working in a variety of places with a variety of people, I have learnt to be more creative". Related to Vygotsky (2004), a violation of the taken-for-granted, a fracture – dissociation – was necessary to promote imagination and create something new: "If life surrounding him does not present challenges to an individual, if his usual and inherent reactions are in complete equilibrium with the world around him, then there will be no basis for him to exercise creativity" (Vygotsky, 2004/1930, pp. 28–29). For some respondents, their creative capacity was perceived to be enhanced when in a state of flow (Csikzentmihalyi, 1990). For example: "Yes, I love writing music. Especially sinking into that creative space where ideas seem to emerge effortlessly and spontaneously. I sometimes think I live for those moments of inspiration".

The vast majority of Swedish, Australian and UK participants were in agreement with the statement "The capacity to be creative helps people to be successful". Seventy-two per cent of both Swedish students and teachers agreed with the

Table 16.2 The most academically successful students are also the most creative

Level of agreement	Students (%)	Teachers (%)	Australia (%)	UK (%)
Strongly agree	7.55	2.78	2.7	3.4
Agree	7.55	5.56	16.2	10.1
Not certain	18.9	5.56	16.2	25.8
Disagree	28.3	27.8	40.5	44.9
Strongly disagree	35.8	52.8	24.3	15.7
No answer	1.89	5.56	–	–

statement. Although a preponderance of the sample population agreed with this statement, the respondents' perceptions did not translate "successful" to an academic context. For example, 64.1 % of the students and 80.6 % of the teachers disagreed with the statement that "The most academically successful students are also the most creative" (Table 16.2).

It is interesting to note this anomaly in terms of what it might connote either about the extent to which creativity is perceived as a "wildcard" in academe, or that the academy is yet to value creativity and its formal credentialing processes appropriately, or both.

Creativity was perceived to enhance academic performance although respondents largely suggested that academic success was not an indicator of level of individual creativity. In the following workshops the participants agreed that creative people were more likely to be good in learning but there were mixed levels of agreement concerning the reverse of this statement (people who are good at learning are more likely to be creative). Interestingly it suggests that while creative people are likely to be good learners, the reverse of this statement is not automatically endorsed. This apparent contradiction may be accounted for as ambivalence around whether academic assessment practices really capture good learning. As one respondent in the UK study noted, the "curriculum encourages mediocrity and acceptance of… facts" (The Creativity Centre, 2006, p. 6). Interestingly one of the Swedish students mentioned how she, during her practice periods, tries to challenge her creativity by using the teaching methods of the Academy courses and playing around with them, in order to internalize and personalize them. This suggests that students, to develop their own creativity, are to make sure to be in places where other creative people are, to be inspired and find support: "I try to develop my ways of working with myself, with my teachers and my students, to find ways that give synergy effects between lesson planed and lesson lived." As the student above, teachers that strive to develop the students' creativity mention how their own creativity is necessary for the results of their teaching: "I challenge myself and I believe in their capacity to reach the goal. I give them positive feedback…I never repeat what has already been done, that reduces my own creativity".

The result from this study indicated that there is a widespread agreement among academic teaching staff and students with regard to the perceived value of developing student creativity – however, the teachers' efforts don't seem to be recognized by the students! Almost 85 % of the students and 94 % of the teachers indicated that developing student creativity is important. The importance of developing student creativity is reflected in the percentage of respondents indicating that they aim to developing student creativity through their teaching practices. Over 94 % of the teacher respondents noted that they aim to develop student creativity. They do this by for example; creating situations with multiple choices, encourage creative solutions (musically as well as pedagogically), being a role model, challenging students experiences and believes, creating a learning environment that is supporting where students formulates their goals, realizing the process and assess the result.

Interestingly, 25 % of the students do not notice this 94 % effort to develop student creativity. One of the students explains:

> Some teachers obviously try. But I think that maybe many teachers are afraid of losing control, to let the students find their own way. They want the students to be creative but in the right way, creative within the frames. That is not creativity to me, creativity is to think and act beyond the frames. (Student X)

Regardless if students answered "yes" or "no" to the question "Do the teachers aim at developing your creativity?" the majority emphasizes the importance of time and possibility to understand and to curiously take on new challenges and different areas of knowledge. In the workshops the overall view was that higher education can develop students creative ability, but only during certain circumstances. Students must be given the possibility to work with assignments for a longer period of time and the assignments should focus on essential themes within the subject. Teachers need to emphasize both process and product and the students must have rich opportunities to explore, examine, experiment and revise. The assignments must also be created in a way that it gives students the opportunity to combine and integrate production with their observation and reflection. Further the students need to have several possibilities to assess their performance and to get formative feedback from their peers and teachers.

There seems to be broad consensus that creativity might be assessable but is unlikely to be so through the traditional assessment instruments used in the academy. Indeed, there was evidence of frustration with the extent to which the exercise of judgment, necessary for assessing creative capacity, was rendered impossible or at least improbable in standard academic assessment regimes. This same ambivalence about context extends to consideration of the "teachability" of creativity, although there was also some residual first generation thinking of creativity as "unteachable".

Aspects of higher music education perceived to promote creativity included: a closer link between teaching and research; slower paced learning for deep reflection; working with classmates on problem-based and project centered learning; and thoughtful and committed teachers. In describing perceived constraints inhibiting the development of student creativity in higher music education respondents indicated that assessment, large classes and poor teaching were primary factors inhibiting student creativity. Respondents also suggested that student demands such as limited time, and flexible learning were major constraints for developing student creativity.

16.1.4 *In, About and Through Creativities – Useful Concepts in Music Education*

The purpose of music teacher education is primarily to develop students' skills in teaching music and to facilitate the learning of their students. The students' learning is arranged in subject studies (musical studies), educational sciences (literature studies) as well as internship or practice in schools. However, my previous research as well as others (Eriksson, 2009) shows that there is a conflict between the so-called theoretical and practical sections in the teacher training. Perhaps more so in music teacher training since the practical section is equivalent with musical studies. Teacher students experience a conflict between encountering a traditional teacher role and an academic perspective on teaching as a profession. The role of the academic music teacher means that decisions and actions of the music teachers are based on scientific knowledge. However, it has proved difficult to integrate scientific knowledge with music as an agency. Rolf (2006) argues that it is only on an analytic, abstract level, that you can separate theory and practice. In all practical knowledge there are systematic theoretical units, patterns based on former knowledge. In the same way theory derives from practice when observations are systemized and patterns detected. Theory and practice are inseparable and naturally influence one another.

Students are at the center of this power struggle. As a student you meet both academics and practitioners who claim ownership of the truth. Nobody gains from maintaining this distinction; it imposes more limitations than possibilities for creativity. The possibility, for all parties, lays instead in seeing how you can use each other's knowledge, experiences and perspectives. Many teacher students also experience a big difference between the academy and the culture of the school environment they came from (Houmann, 2014a). Within the academy another set of norms exists, another language, other ways of thinking and solving problems and of course another way of being. To be able to oscillate from one approach to another is not easy. Bron (2000) introduces the theoretical concept "floating" as the basic state for the identity of the self, its place and belonging. The concept includes a sensation of being fragmented, of not having a past, and not being able to create, or plan for, the future. In academia you are confronted with different messages and new perspectives, but they don't seem valid. The old way of doing things is no longer enough. It's like being on a raft without being able to navigate. To be able to develop as a person and as a student you need to be challenged and at the same time given the opportunity to connect previous experiences with new. To bridge that gap we use biographicity (Alheit, 1995) and reflexivity (Ziehe, 1997) as theoretical standpoints in all educational sciences courses within music teacher education. I will give some examples of how this is done later on.

Another way of challenging students and to give them the opportunity to connect previous knowledge with new is , rather than defining studies at the academy according to the concepts of theory and practice, to talk about learning *in*, *about* and *through* (Houmann, 2010). "In" stands for action knowledge, knowing in action

(Schön, 1987), tacit knowledge (Polanyi, 1966), what we know but cannot explain, "about" is knowledge in general about teaching and "through" stands for knowledge that for example takes place in the teacher training internship. Music education research as an academic subject can be studied "in", "about" and "through" creativity, by letting these concepts be a link between theory and practice.

The findings from the "Creativities Transcending Boundaries" – project were useful in terms of determining whether and how the policy commitment of higher music education to develop creative capacity in staff and students alike could be enacted in higher music education teaching and learning. They show "second generation" thinking as emergent, while not yet being dominant, in the perceptions of these participants. The shift away from "first generation" thinking are important if any attempt is to be made to bridge the gap between policy rhetoric and teaching reality. The fact that these academics were a select group of teachers and students within higher music education does give some cause for concern about the speed of uptake of second generation thinking among those academics that were less acknowledged and rewarded for their teaching. This suggests there is still much work to be done to engage teachers and students with creativity as a hard-edged professional capacity that can and should be fostered through higher music education teaching and assessment.

Recommendations for disseminating "second generation" thinking about creativity capacity building through higher music education and teaching was made and implemented in to the new teacher training in 2011. With the use of the concepts dissociation and hybridity, biographicity and reflexivity we shaped the collaborative and including development project that was underpinned by our study on creativities in higher music education. On a practical level the experiences from this project was implemented in the curriculum of the courses in educational sciences. The courses in educational science have been developed alongside the workshops based on the results discussed so far in this chapter. We also created a webpage where all results are described and all research and literature about creativity is on display in a web-library (www.creativities.org). In the next paragraphs I will provide examples of the work that gave creativities a voice in Music Teacher Education.

16.2 Giving Creativity a Voice in Music Teacher Training

Creativity and invention have long been seen as a "black box" in higher music education (Houmann & Sæther, 2014). As mentioned before, higher music education don't typically, explicitly, try to understand this process. We fully expect that when musicians, as creative people, go into a room with a goal, they will come out with more or less creative discoveries and results. Although when we watch them at work we can observe some combination of playing, sketching, animated conversations, fine tuning instruments and bodies and messy floors. The fundamental nature of what happens in that room remains mostly a mystery. As a music teacher you just become, to some degree, creative.

Through several research projects (Houmann, 2010, 2014a, 2014b, 2015a, 2015b) we have been unveiling and describing the creative process that takes place when and how "it" happens in music teacher training and in music teaching. Consistently, in creating the setting for these projects inspired by Cirkus Cirkör (Björfors & Lind, 2009), we have chosen to put as much energy into the pedagogical part as the artistic part. With these two paths nurturing and inspiring each other, and an artistic approach to the professionalization of music teachers the development curve of the courses within educational science is nowhere near straight. Quite far from it! With all the success, all the failures, all the anxieties, new activities and leaps into the unknown, it pretty much resembles a rising ECG. The most important thing that we can share from our evolution is what the musical disciplines and our key words remind us of. At every crossroad, when decisions are to be made we ask our selves: What risks are we taking and are prepared to take? Who is risking what? Are we comfortable? Are we too comfortable? Do we need to get out of our comfort zone by taking a risk? What is the element of seriousness? Are we enjoying ourselves? So contradicting the current and political ideas stating that the arts should be more aligned with curriculums and assessment systems, the example of our life curve shows that it is in fact possible to let curricula and assessment be inspired by the arts.

Teaching for reflection in, about and through creativity (Houmann, 2014a) requires a pedagogic stance that is facilitative, enabling, responsive, open to possibilities and which values process as much as outcomes. As one example we use a specific method where music teacher students reflect on their teaching by visualizing the role of the multidimensional music teacher by creating a three-dimensional artifact. In this way the students acknowledge the concepts, personal qualities or skills that they believe are included in the "multidimensional music teacher". The purpose of the practical assignment is to get the students to describe the web of musical, pedagogical and social experiences that the music teacher creates in his or her work. By using self-reflection and autobiographies in this way music teachers reflect in, about and through creativity – and at the same time, through artifact making, creates a key to the life-world of the music teacher (Houmann, 2010, 2014b, 2015b). Hence you can see the artifact making process as a figuration of the life-world as an intentional world, lived world and a social world (Bengtsson, 1999; Merleau-Ponty, 1962/1999; Schütz, 1953/1999). Alheit (1995) writes about the hidden capacity to lead our own lives that can be set free through work with life-stories, where knowledge and learning is in focus. Knowledge about biographical learning helps us to understand the identity changes that our students go through. They shift their identity or move between multiple identities and roles depending on context and situation. Through the biographical reflection and interpretation in the construction of the three-dimensional artifact, that is reflection and interpretation of what has been, in the light of what is and in the light of what is planned, more alternatives become visible and can enable new and alternative routes in life. Often this means seeing an opportunity to make other choices that we earlier believed as possible or been aware of. Here the maxim of Søren Kierkegaard also applies: "Life can only be understood backwards; but it must be lived forwards".

Drawing on biographicity and autobiography as a tool for working with creativity in higher music education, another example is the method "The soundtrack of my life" (Houmann, 2015b). In the first course in music teacher training students are asked to write an autobiography using music as a focal point in their stories. The students seek their identity through previous learning and experience and by doing so try to understand their current situation and context. They have to choose five pieces of music that they would describe as "crossroad music" or a "string of musical pearls" that together would form "The soundtrack of my life". Four of the five pieces should be music that they have listened to or played, or that others (parents, friends, teachers etc) have listened to or played that in some way inspired, motivated and changed or developed them. The fifth piece should be a piece or a song that they have been "ashamed" of. It could be either a piece of music that they have felt alone listening to and enjoyed or a piece that they felt they couldn't stand for in a musical context. From these five pieces of music they have to structure their autobiography in four themes; me and my music, me and my teacher, me and my school and me and my choice of profession. After individually writing their autobiography they get into groups of four. They then read each other's biographies and analyze each story. The students then move into the third stage of the process. The four autobiographies are then to be merged into one musical presentation. All the groups have a 15-min time limit for their presentation. During this process they can choose different means of collaboration, tools, themes and focal points. They can pick parts from each autobiography or just pick one autobiography to perform. By processing the biographies in this way the students become partners in an investigative process (Dominicé, 2000). The students then present, often very creatively, which categories that have submerged or how theory can be understood in or through practice. In turn, this presentation often leads to further reflection and implications for the teacher students and teachers.

16.2.1 When Music Puts the Questions

A third example of how creativity is given a voice in music teacher training is the project called "Creativities at Inter Arts Center". During the first year in teacher training students go in to internship. Besides supervised teaching they are also to investigate and identify music teachers' discretionary power and put their results in a report. Discretionary power is defined as "having the opportunity and knowledge to exercise one's own professional judgment in carrying out and making decisions in daily work" (Houmann, 2010, p. 1). It is identified by analyzing music teachers' possibilities and limitations through knowledge, actions and motivation. Students bring their results to a project week where researchers, teachers and students together examine, explore and experiment on possible ways to develop music teachers' discretionary power. During that week the students, based on their findings, come up with project ideas with the purpose to develop discretionary power in a school environment. They give a 5-min pitch of their ideas in front of an audience and it is documented on video. After that the student analyze their pitch and audience feedback and develop their oral presentation into a 15-min pitch that is done with representatives from the internship in the audience. At the end of the period the project plans will be sent back to the schools where the student had their internship.

Inspired by Van Schalkwyk (2002) the students' observations are summarized into a report using the concerto form from the Westerns classical music as a metaphor for structuring and presenting their data. Many students often experience paper/report writing as a challenge when it comes to making sense of the mounds of literature surveys, data and analysis. Let alone writing the actual report. For many music teacher students it is like learning to play a new instrument. The main challenge is to find a framework for representing the end product that will convince the reader of the legitimacy of the scientific endeavor. In systems thinking metaphors are generally accepted for constructing realities about life (Indurkhya, 1992). This requires creativity to find "projective (similarity-creating) methapors…[where] the source concept network is interpreted in the target realm, as if the target realm is being encountered for the first time" (Indurkhya, 1992, p. 281). A musical composition reflects such structure and co-operation in the way the elements work together to form a coherent whole (Minai, 1995; van Schalkwyk, 1998). The intentional activity of the composer-music system evolves in much the same way as the process of conceptualizing a model for understanding and explaining a particular phenomenon, in this case discretionary power.

The report is like a composition and the student writing it, is the composer. The process or intentional activity is a co-creative dialogue (some kind of doing) between the student (a doer), the body of scholarship and the conceptualizing of theoretical propositions for a coherent model (something done) within a given context (Van Schalkwyk, 2002). In this process of "doing something" the student becomes aware that the timbre (tone or inflections), pitch (slant or bias), time (duration) and dynamics (plausibility and forcefulness) of many viewpoints may differ, although they merge together in the co-construction of new arguments and viewpoints on discretionary power. The rhythm is set in the alternation between supportive and new arguments, whereas the melody is found in the flow of clear and precise language. On the whole, through the intentional activity of conceptualizing the coherent representation of the study, propositions and suppositions are bounded together in harmony, and ideas alternate similarly to the different tonalities in a musical composition.

We found the musical form to be a suggestive metaphor where the concept network of the sonata form is used to provide an initial ontology for describing the different sections of the report. In this way the metaphor became a vehicle for organizing and systematizing the information in the different chapters so that the report could evolve as a coherent whole creating a continuity of ideas, and developing the theoretical propositions as themes in a dynamic unitary system; overture, exposition, development, recapitulation and cadenza/coda. We ask the students to keep in mind: What happens when music puts the questions and shapes both content and structure of the report? By doing so the students identify music teachers' discretionary power – their possibilities and limitations.

Student reports evokes that today's complex and high-speed environment are calling music teachers to engage multiple styles of leading and learning. They need to know how to generate collective intelligence and how to call on everyone's participation and leadership. They need to generate shared clarity of purpose and create spaces for nonjudgmental learning. At the same time, music teacher students experience that they are asked from the policy makers to exercise hierarchical leadership. They are accountable to stakeholders and must take decisive action when needed. The goals for the subject music are stipulated in a chain of cause and effect but a creative process creates something different: not a chain but a framework for exploration, experimentation and trial and error. The path to the goal is not clear, and the goal may in fact change. Learning how to stand in this paradox and how to navigate the territory between too much chaos and too much control is the key for the upcoming project week of exploration. In this week student practice staying focused and centered in the midst of both chaos and control. They share stories from practice, education and previous experiences about teaching and learning creatively. It involves sharing learning and experiences of what happens when we engage in to co-learning and co-developing solutions to complex challenges. It also involves the practice of participatory leadership when leading creative processes in the project week, a week full of exploring and experiments through games.

16.2.2 The Game of Music Education

One part of Meads (1934) theoretical argument is perspective and perspective taking. The focal point for these thoughts is the self in terms of "I" and "me" and their respective relation to the "generalized other". By this Mead refers to society and/or the group that the individual perceive it belongs to. The mutual values and norms that exists in a society or a group Mead defines as the generalized others attitude, which can be understood as both the point of view and the approach that a society or a group takes in different regards. This concept is essential for example phenomenon's as socialization, learning and meaning making. When the part of the self called "me" develops it builds on what Mead calls "take the role of the other". You learn this through "play" but foremost "game". The distinction Mead is making between the processes play and game is that play is a form of imitation of others at the same time as it transcends imitation. Game means taking it a step further than what is done in play. If we consider a game of chess it is not only about planning your own moves but also thinking about you opponents next move. Preferably in as many moves and alternatives as possible to be able to do a good move yourself and thereby winning. Game, in other words, is about your actions being guided by interpretations of the others imaginable actions in the situation you are situated in. To be able to do this it requires a more advanced way of taking the role of the other than in play. I have to try to understand how the other person is thinking – how is he or she understanding this situation right now? I have to be me and the other at the same time to be able to predict what the next move/step is in a certain context. The basis of these reflections are "me" and "the generalized other", hence the socialization that we have been apart of all our lives together with all we have learnt. Taking the role of the other is something we also practice as adults. We have good use of this, in the same way as predicting chess, in the social interaction that plays out between humans. Likewise understanding of the generalized others attitude is practiced and learnt continuously (Goffman, 1959).

During the project week students use different games to explore, examine and experiment, taking the role of the other (Mead, 1934) with musical formats as a focal point. The purpose of the week, besides investigating a theoretical phenomenon (discretionary power), is to examine what it takes to consciously design and host creative processes that deepens students' dialogue and leadership skills. Teachers introduce the elements of design, mental frameworks to understand how to work with emergence and complexity, and practical tools to support the students. Designing games the teacher and research team worked like a composer during the project week orchestrating the activities to achieve the right harmony between creativity, reflection, thinking, energy and decision making. Opening (divergent), exploring (emergent) and closing (convergent) are the core principles that helped to orchestrate the flow and get the best possible outcome from the creative processes during the project week. Each of these phases is different and it is important to know where you are in the process and what is needed in each phase. The first phase opens the world by setting the stage, introducing the players, and developing the themes, ideas and information that will populate your world. In the second phase you will explore and experiment with the themes you developed in phase one. In the third phase you will come to conclusions, make decisions, and plan for the actions that will serve as the inputs for the next thing that happens, whether it's another game or something else.

Invited with the question "how can we revitalize music education?" students initially embark the method Open Space Technology (Owen, 1997). To the first session of the week students bring their key findings or rather ideas for development of music teachers possibilities. Their ideas create the agenda for the day in a bulletin-board fashion. These items become potential breakout session, and participants have the freedom to "vote with their feet" by moving between breakouts. The goal of an Open Space Technology is to create time and space for people to engage deeply and creatively around issues of concern to them.

Dialogue sessions convene and each group captures the important points and post the reports on the news wall. All the reports end with a project idea that could be pursued during the project week. The students then chose which project they would like to develop by "dot voting".

Using the concept "Kubus" (Herlau & Tetzschner, 1995) the project idea is subject for exploring, examining and experimenting. The Kubus concept consists of the Kubus model that has been elaborated as a form of teaching-based research and has consisted in living out problems centering on entrepreneurship and innovation in a forward-looking perspective. The model focus on the phase prior to when the basic idea and management has been determined, when project management theories come into play, the *preject*. Herlau and Tetzchner have done this because students' increasingly demanded to be instructed *in* how to lead the innovative process rather than *about* how it can be led. It is a great change from textbooks, power-point presentations and blackboard instruction to working in interdisciplinary self-managing groups, which are seeking a practical path toward very uncertain goals without a fixed leader, groups that can absorb the complexity, uncertainty and conflict on the path toward a well-defined goal. The Kubus model is a management model with shared management, which is designed for managing the work of interdisciplinary group in the early phases of the innovative process. The model has been developed in order to create a kind of operative framework so that relevant knowledge can be created as the point of departure for communication in the group. In the Kubus model, leadership is divided into two sharply distinguished functions: a process function and a result-oriented function. Leadership is exercised actively by all members of the group, who, on the basis of knowledge of the functions manifested by the leadership in the group work, support the leadership function through their actions of making themselves managerial. In practice, the team members are allocated leadership functions on the basis of a rotation principle, such that all members assume work tasks in order to highlight the leadership functions.

Results from the project week shows that music teacher students tend to employ simple strategies and practices to get where they want to go. It's not so much that they employ a consistent, repeatable process that leads to consistent creative results. It's more like a "workshop" with a set of tools and strategies for examining things deeply, for exploring ideas, and for reforming experiments and testing hypotheses, to generate new and surprising insights and results. Within teacher training in higher music education ideas and people cross-pollinates like bees in a single massive hive. The practices we live in are mostly an oral culture, passed along from person to person by word of mouth, or sound of play. In this week the students enters a space that is set to investigate and map this process and by that giving creativity a clear and firm voice in music teacher training.

16.3 Coda

Creativity in music education, like many other human activities, is built around goals. Goals are a way me move from A to B; from where we are to where we want to be. A goal sets up a tension between a current state A – an initial condition – and a targeted future state B – the goal. In between A and B is something we can call the challenge space: the ground we need to cover in order to get there. In music teaching we need to manage for creativity – in effect, we don't want predictability so much as breakthrough ideas, which are inherently unpredictable. In any creative endeavor, the goal is not to incrementally improve on the past but to generate something new. So, if a student wants to truly create, there is simply no way to precisely define the goal in advance, because there are too many unknowns. Embarking on this kind of adventure is akin to a voyage of discovery.

In a creative process goals are not precise and so the way we approach the challenge space cannot be designed in advance, nor can it be fully predicted. This is true at both a micro scale and a macro scale. Because the goal cannot be determined precisely in advance, some parts of music teaching must proceed on intuition, hypotheses and guesses. This may seem like a big challenge, but the world we create does not necessarily need to be complicated to be interesting and to help us move forward. Imagining a world can be as simple or as complex as you want to make it, depending on your goal, your situation, and the time you have available.

> Unlike a large and complex process, which must be planned in advance, a concept of operations is under constant revision and adjustment based on what you learn as you go. So, yes, you need to have a goal, but since you really know very little about the challenge space, it's very likely that your goal will change as you try out ideas and learn more about what work and what doesn't. (Student X)

Blackwell, Wilson, Street, Boulton, and Knell (2009) identifies fuzzy goals as a pole-star vision as an essential element of successful innovation. It is "a goal that motivates the general direction of their work, but without the need to get there blinding the team to opportunities along the journey" (p. 13). Important factors include the balance between focus and serendipity and coordinating team goals and the goals of individual collaborators, which easily can be transferred, to the actual situation of the music teacher in the classroom. Fuzzy goals in music education straddle the space between two contradictory criteria. At one end of the spectrum is the clear, specific, quantifiable goal and at the other end is the goal that is so vague as to be, in practice, impossible to achieve. In music teaching goals must give students a sense of direction and purpose while leaving them free to follow their intuition.

Music teachers need to navigate ambiguous, uncertain and often complex information spaces. In many ways it's a journey in the fog, where the case studies haven't been written yet, and there are few examples of where it's been done successfully before. "Voyages of discovery involve greater risks and more failures along the way than other endeavors. But the rewards are worth it" (Student X). Creativity can be your foghorn in higher music education if the cards are played well.

- There seems to be broad consensus that creativity might well be assessable but is unlikely to be so through the traditional assessment instruments used in the academy. Indeed, there is evidence of frustration with the extent to which the exercise of judgment, necessary for assessing creative capacity, is rendered impossible or at least improbable in standard academic assessment regimes.
- The findings from our research projects are useful in terms of determining whether and how policy commitment of universities to developing creative capacity in staff and students alike can be enacted in higher education teaching and learning. The findings also suggest that "second generation" thinking is emergent, while not yet being dominant, in the perceptions of awarded academic teachers. The shift away from "first generation" thinking are important if any attempt is to be made to bridge the gap between policy rhetoric and teaching reality.

- Creating an organization that takes inspiration from the art form could engage academic teachers with creativity as a hard-edged professional capacity that can and should be fostered through higher education teaching and assessment.
- Music is full of metaphors. To let music put the questions is to decipher what it really means to have practical specialist qualifications. We: students, teachers and researchers examine the dimensions of the music disciplines in relation to art and society. Until today, the disciplines have continually challenged us to question and think deeper and bigger.
- Contradicting the current and political ideas stating that the arts should be more aligned with curriculums and assessment systems and be more inspired by the business world, the example of our life curve shows that it is in fact possible to let curricula, assessment and business be inspired by the arts.

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Chapter 17
Children's and Teachers' Conceptions of Creativity: Contradictions and Implications in Classroom Instruction

Eunsook Hong, Rachel Part, and Lonnie Rowell

Abstract Personal beliefs about a construct are formed based on individuals' experiences in sociocultural contexts. Personal beliefs are powerful as individuals tend to plan, take actions, and evaluate their own and others' actions based on their belief system. In this chapter, we review pervasive creativity myths, followed by an examination of teachers' implicit theories of creative children and creativity and children's views of creative people and creativity. Contradictions found between teachers' conceptions of creativity and classroom practices and discrepancies between teachers' and children' creativity conceptions are discussed along with instructional implications. Themes of contradictions include: (a) Yes, developing creativity in students is important, but no, not my priority; (b) I may do it if things are ready for me; (c) I am almost there, but they are not; (d) Creativity is art; (e) Amicable trait, but not in my class; (f) Not in our culture; (g) Anyone can be creative; sounds good, but really?; and (h) Assessment of creativity? I have no clue. We underscore the need for professional development and offer a few items that might help in teacher preparation for classroom instruction.

17.1 Introduction

To most people the word "creativity" means goodness, making new things, and enriching and advancing humanity. Yet, creativity is elusive, mysterious, and inexplicable to many. This phenomenon has persisted even though creativity has been a subject of dialogues among philosophers throughout human history and a subject of research by scholars from various fields. Ancient cultures developed mythical

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stories about things and events that cannot be explained by existing knowledges. Myth generation has continued throughout human history as humans have encountered inexplicable phenomena. Although research has advanced the understanding of creativity, there is still ample evidence of the pervasiveness of creativity myths in today's society. In this chapter, we review pervasive myths, followed by explication of contradictions demonstrated in children's and teachers' beliefs about creativity and their implications in classroom instruction.

17.2 Creativity: Everlasting Myths and Stereotypes

Views of creativity as expressed by Plato (divine inspiration), Aristotle (human nature, improvisations and gradual improvements), Kant (inborn predisposition), and Schopenhauer (skill mastery and immersion) (Aristotle, 1951; Kant, 2000; Paul & Kaufman, 2014) are still present in today's popular conceptions of creativity. Shattering long-held myths is not easy. It is tempting to think that perhaps early education for creativity may help break the hold of persistent misconceptions. Unfortunately, children's creative potential is largely uncultivated in today's schools.

Children in preschool and kindergarten are incipient scientists and artists. As they enter formal schooling, room for creative thinking shrinks. Many reasons have been put forward to explain this shrinking of creative space, for instance, pressure of content coverage and lack of teacher training (e.g., Chien & Hui, 2010; Hong & Kang, 2010). Another prevalent reason that is not unrelated to schooling is the misconceptions and myths about creativity that permeate our society. Most laypeople associate creativity with big name artists, scientists, and inventors. It is not surprising that the creative process seems enigmatic to most people. In this section, we briefly discuss the types and sources of pervasive creativity myths.

17.2.1 Art Bias

Creativity is essential in all areas of human endeavor. Yet, art has dominated when it comes to creativity for a very long time. Art bias regards the misunderstanding that occurs when creativity is equated with artistic talent (Runco, 2007). Immanuel Kant (2000), defining genius as the capacity to produce ideas that are original and exemplary, maintained that genius occurs only in the fine arts and that scientists just follow rules required for scientific method. This notion persists to the current day. In education, science subjects have rarely been linked to the utilization of creative thinking (Hu & Adey, 2010).

However, the art bias seems to be diminishing. A recent article, "Revisiting the 'art bias' in lay conceptions of creativity" (Glăveanu, 2014), shows some evidence. Glăveanu found that although artistic professions were scored the highest in creativity by research participants, when they were asked to generate questions to determine whether an object is creative, the questions were not as focused on generating art-related items. This was a further development from Glăveanu's (2011) earlier research where he found a predominant art bias when participants were asked to propose a symbol for creativity (e.g., paintbrush) and statements linking symbols with creativity.

17.2.2 You Have It or You Don't

The old nature-or-nurture issue in regard to intelligence applies to creativity as well. Views about creative ability in early human history progressed from the notion of divine inspiration in ancient Greek culture to the inborn-talent conception of Romantic idealism in the nineteenth century (Cooper & Hutchinson, 1997; Singer, 2011; Weiner, 2000). These early views did not leave much room for the developmental capacity of human creativity (Boden, 2004; Kant, 2000).

Fast forwarding to the current era, the notion that "people are born creative or uncreative" is still discussed in literatures (Plucker, Beghetto, & Dow, 2004; Treffinger, Isaken, & Dorval, 1996). For decades, creativity literatures have been replete with stories of eminent creators (e.g., Simonton, 1984, 2015). Unfortunately, this enduring notion leaves no room for awareness or appreciation of the creative potential that all individuals have. This is particularly unfortunate given the numerous published works that have documented positive effects of creativity instruction on increasing creative ability (e.g., Amabile, 1983, 1996; Torrance, 1972, 1987; Westberg, 1996) and literatures that directly or indirectly challenge the idea of being born creative or uncreative (Kaufman & Beghetto, 2013). As much as the eminence bearers, also called the Big-*C* creatives, have made significant contributions to society, this conception has become a source for continued mystification of creativity, as Big-*C*s are often viewed as mysterious people who do marvels. However, recent work on Four *C*s (Big-*C*, pro-*c*, little-*c*, and mini-*c*) helps researchers and educators re-conceptualize creativity (Beghetto & Kaufman, 2007, 2010a).

17.2.3 Teachability

Whether creativity is teachable or learnable is closely related to the topic discussed above, that is, you are born with it or not. Most people who presume that creativity is inborn will likely think that creativity cannot be taught. Philosophers such as Kant (2000) who consider learning as nothing but imitation (i.e., incongruous with creativity) deny the possibility of teaching creativity. Contemporary philosophers have different views. Gaut (2014)), analyzing two arguments regarding learning—imitation and rules—produces a convincing general argument as to why some people can be taught to be more creative. He utilized two constructs as component dispositions for learning creativity: intrinsic motivation (that he described as not hard to teach) and the ability to produce new and valuable things and to evaluate products. We appreciate the effort of philosophical arguments in support of the teachability of creativity. However, there also have been quite a few research evidences that people can learn to be more creative (Bolden, Harries, & Newton, 2010; Cheng, 2011).

17.2.4 Madness, the Creatives

The traditional or stereotypical concept of the "mad genius" has been disputed in the literature (e.g., Eysenck, 1993; Schlesinger, 2009), although there have been quite a few cases that demonstrate the existence of the relation between creativity and mental disorder (e.g., Ludwig, 1995; Nettle, 2006). Methodological problems aside in the study of this association (Schlesinger, 2003), there are also moderating variables that muddy mad-genius claims (Ludwig, 1998; Richard & Kinney, 1990). Nevertheless, from Plato's description of genius as a state of divine insanity (Abel, 2013) to Lombroso, a philosopher and psychiatrist in late nineteenth century (Rothenberg & Hausman, 1976) and James, a philosopher and psychologist (Burton, 2009), who related genius to psychopathy, the notion of madness and creativity has persisted.

Maslow (1968), unlike the contemporary creativity scholars, viewed creativity ("creativeness" in his word) as a component of self-actualization. Distinguishing special talent creativeness from self-actualizing creativeness, he describes the latter emanating from personality. He portrays creative people as being less inhibited and open to new experience and as expressing ideas without fear, like happy and secure children. They may be a bit nutty and crazy as Maslow described them, but he did not go so far as to characterize creativeness as madness.

17.2.5 Individual or Group

While some scholars discuss the myth of the lone genius, arguing that individualism and methodological reductionism have prevented researchers from examining sociohistorical context and its relation with creativity (Montuori & Purser, 1995), others (Plucker et al., 2004) argue that it is individual creativity that has suffered due to the notion that creativity is enhanced within a group. Based on creativity work on group-related factors (Simonton, 1984; Stein, 2003), Adarves-Yorno, Postmes, and Haslam (2006) find that creativity in groups varies depending on social identity and group norms. An individual's idea is not creative until it is perceived as such by group members or society, emphasizing the importance of social processes, for example, evaluation of creative processes and products, for the recognition of creativity.

Although societal influences on creativity generate unique perspectives of creativity, Rao (2005), analyzing a scientist, a mathematician, and a novelist from different countries, identified the transcultural nature of creativity. Then again, numerous cross-cultural research studies have shown cultural and societal influence on creativity (e.g., Niu & Kaufman, 2013; Ramos & Puccio, 2014; Zhou, Shen, Wang, Neber, & Johji, 2013) and how sociocultural contexts promote and constrain individual's experience of creativity (Csikszentmihalyi, 1999; Lubart, 1999; Sternberg, 2007). Even within similar ethnic groups, differences are found in creativity perceptions across countries due possibly to the ways individuals were raised in different societies and educational systems (Rudowicz & Yue, 2000; Seng, Keung, & Cheng, 2008).

17.2.6 Knowledge: Facilitate or Impede

The notion of divine inspiration lends an impression that creative ideas just occur by chance and that one does not need to work hard to get them. Expert knowledge in a particular domain influences idea generation and idea modification in response to demands within the domain (Boden, 2004; Johnson-Laird, 1987). Although too much knowledge was viewed by some scholars as an impediment to creative development (Simonton, 1984; Sternberg, 2006), the general consensus is that profound knowledge and extensive skills are necessary for creativity to emerge (Bilalić, McLeod, & Gobet, 2008; Csikszentmihalyi, 1997; Gardner, 1993; Weisberg, 1999). Abel (2013), rejecting the "lazy genius" myth, gave a few examples of the creative eminent; Picasso, for example, mastered the painting techniques of his time well before he developed his own techniques. In-depth analyses of how the presence and absence of domain knowledge leads to the development of different patterns of creative process, and in what ways domain knowledge benefits or constraints the creative process, beyond well-known expertise examples such as chess, warrant further investigation.

17.2.7 Section Reflection and Prelude

As conceptions of creativity have seen changes over time and with genius myths on the wane, we believe that it is time we focused on how we can advocate for a more democratic conceptualization of creativity, so all humans can begin to be aware of their own creative potential and to exercise actualizing it. The term "creative economy" has been showing up in books and articles (Florida, 2006), even in early childhood education (Eckhoff & Urbach, 2008) and educational policy literature (Yeh, Tobin, & Karasawa, 2004), following the trend set with the term "knowledge economy" as a part of restructuring global economy by strengthening awareness of the relation between education and labor force. One wonders who is benefiting from this orientation, especially in education (see Giroux, 2013 for extensive discussion). We wish to emphasize that we do not see our advocacy of creativity as associated with a global-economy restructuring that focuses on developing human capital. On the contrary, literatures on creativity in education have also underscored creativity as a source of personal fulfillment and social good (Banaji, Burn, & Buckingham, 2010; Gibson, 2005), and our intention is aligned with this orientation. It is not necessary to tie all human endeavors with economic imperative. This may sound antithetical in the current climate of creativity and innovation, but whether constant fast-paced changes and innovations that breed generations of followers of innovations is a desirable way to portray creativity is a good question to ask.

Although contributions of creativity work to society have been expanded to various areas beyond the arts (Plucker et al., 2004), support for creativity in education, especially in the classroom, seems to be emerging very slowly. While various nations have recognized the importance of creativity in education and have called for infusing creativity into curriculum and instruction (e.g., Chien & Hui, 2010; Choe, 2006; Craft, 2001, 2003; Shaheen, 2010; Tan & Law, 2004; Thompson, 2009), how much the call has been translated into implementations in schools is not clear (e.g., Park, Lee, Oliver, & Crammond, 2006). Furthermore, high-stakes, mandated testing as well as content standards have been adopted increasingly in various nations, and these mandates pose major barriers for implementing creativity in education (Beghetto & Kaufman, 2009; Hong & Kang, 2010; Meyer & Lederman, 2013; Wiliam, Lee, Harrison, & Black, 2004). Although there have been earnest efforts to encourage and nurture creativity in the classroom (e.g., Barron, 1988; Beghetto & Kaufman, 2010b; Hennessey & Amabile, 1987; Sternberg, 1996), it is difficult to know how much impact they have produced.

There are various reasons for the lack of meaningful adoptions of creativity in schools. In an effort to understand this phenomenon from children's and teachers' standpoints, we examined their personal beliefs or personal theories, also called implicit theories (Runco & Johnson, 2002), about creativity in the following section.

17.3 Teachers' and Children's Conceptions of Creativity

Personal beliefs are powerful, as they are not obvious but work rather instinctively. Teachers bring their beliefs and values to teaching in addition to their content and pedagogical knowledge and skills. Likewise, students bring their beliefs to the classroom, along with different personality types and ability levels. It is the instinctive and unconscious nature of implicit theories that make them influential in the classroom. Thus, it is not surprising to find that there have been quite a few studies investigating teachers' implicit theories of creativity, although research on children's theories is quite limited.

Most individuals engaging in creative activities do not likely think about theories defined by scholars, called explicit theories, but they are more likely guided by their own implicit theories when planning, implementing, and evaluating creative abilities and activities of their own and others. Personal beliefs about creativity are formed based on their experiences in sociocultural contexts and are powerful in predicting creative performance. Saunders-Wickes and Ward (2006), for example, found that implicit theories of creativity were a more consistent predictor of later creative activities (hobby participation and performance on creative task) than performance on paper-and-pencil tasks, demonstrating the impact of personal beliefs of creativity on creative behaviors.

This is not to say that explicit theories are not as valuable as implicit theories. It is an acknowledgement, however, that knowledge from research findings is seldom shared with laypeople, as they do not have easy access to research literature and rarely read research articles, as these research products seem to speak languages understood by scholars and are shared almost exclusively amongst them (Jacoby, 1987; Kristof, 2014). Although it is acknowledged that teachers' classroom practices are based on many factors beyond their beliefs and past experiences, the focus on implicit theories is an important step towards increasing teaching of and for creativity. We discuss teachers' conceptions of creativity, followed by findings of a recent study on middle school children's conceptions.

17.3.1 Teachers' Conceptions of Creativity and Creative Children

Although the importance of integrating creativity in education has been called for since decades past (Guilford, 1950; Torrance, 1976), the call seems to have been largely ignored by the educational community (Kaufman, Beghetto, Baer, & Ivcevic, 2010; Torrance, 1995). Various research evidences showing a strong relation of early creative thinking and creative activities with adult accomplishments (Hong & Milgram, 2008; Milgram & Hong, 1999; Plucker et al., 2004) seem to have had no impact on classroom practice. To change this scenario and to foster student creativity in the classroom, teachers should be ready for the task.

Yet, regarding this preparation we have more questions than answers at this time. Are teachers aware of the importance of creativity as an important human endeavor? Can they recognize creative potential, creative personalities, creative processes, creative products, and creative environments? Has teacher education paid attention to these issues or even begun to think of creating courses for teaching for creativity and for creative teaching? Given that it is well past time that educators from preschool to higher education give serious thoughts on these issues, a certain urgency is needed in beginning to address these questions.

Teachers hold a critical role in efforts to foster children's creativity in schools through shaping learning environments that are conducive for developing creativity. Efforts to marginalize and mechanize the role of educators aside (e.g., Giroux, 2014; Ravitch, 2013), teacher's beliefs still have a large impact on the choice of tasks, communication of concepts to students, instructional approaches, and recognition and assessment of student work (Pajares, 1992). Thus, understanding teachers' beliefs about creativity and creative children are important before designing and implementing educational programs for the development of creative ability (Chien & Hui, 2010). We discuss teachers' conceptions of creativity and classroom practices where available.

Teachers' Descriptions of Creative and Uncreative Students Quite a few studies have examined teachers' conceptions of creative and uncreative children (Aljughaiman & Mowrer-Reynolds, 2005; Chan & Chan, 1999; Diakidoy & Kanari, 1999; Runco & Johnson, 2002;Runco, Johnson, & Bear, 1993; Zhou et al., 2013). Although teachers' descriptions of creative children depended on the nature of questions and the measures used in research, some common characteristics emerged across studies.

Teachers viewed creative children as imaginative, original/unique, curious, intelligent, artistic, and independent/autonomous (these were shown at least four times across studies), and innovative, with wide interests, confident, constant questioning, quick in responding, and active (shown at least three times across studies). Other descriptions of creative children reported in at least two studies included risk-takers, adventurous, enthusiastic, humorous/witty, talented, active, flexible, self-directed, expressive, and deep-thinker. Teachers also expressed creative characteristics as negative, including non-confirming/challenging/rebellious, impulsive/uninhibited, dreamy, self-centered, and arrogant. Teachers characterized the following as uncreative for those children who are: cautious/timid, conventional, conforming, or pessimistic (shown at least two times across studies). Teachers viewed arrogant and self-centered children as creative as well as uncreative across different studies (Chan & Chan, 1999; Crow, 2008; Runco et al., 1993). These findings indicate that although teachers agree on many characterizations of creative children, teachers as a whole are not certain about what constitutes creativity.

Teachers' Conceptions of Creativity

Several studies examined teachers' conceptions of creativity (Aljughaiman & Mowrer-Reynolds, 2005; Cheung & Mok, 2013; Diakidoy & Kanari, 1999; Hong & Kang, 2010; Panaoura & Panaoura, 2014; Park, 2013; Runco & Johnson, 2002; Runco et al., 1993; Zhou et al., 2013). Not surprisingly, teachers perceived creativity as originality/novelty/uniqueness, imagination, artistic ability/products, divergent thinking, tangible products (e.g., creative writing), inventiveness, or problem solving (these were shown at least three times across studies). Teachers expressed that creativity can be developed or taught (shown at least four times across studies).

When teachers were prompted to express their views about factors that facilitate or impede creativity, independence and motivation were considered important characteristics for the development of creativity. Chinese teachers identified critical thinking, independence, and motivation as important attributes, while German teachers regarded encouragement and feedback, independence, and initiatives as important (Zhou et al., 2013). Greek preservice teachers considered autonomy and independence, followed by intrinsic motivation as crucial attributes (Diakidoy & Kanari, 1999). Creating teaching environments such as providing opportunities to correct mistakes, for assignment choices, and to question assumptions were considered as important conditions for fostering creativity. Also mentioned by the same research participants, however, were some questionable approaches, including use of frequent praise, external rewards, competition, evaluation, and following instructions. Although these are not necessarily detrimental (e.g., if rewards were matched with creative performances), teachers should understand the ramifications of these teaching practices. Chinese teachers thought the evaluation system and lack of resources were hindrances for fostering creativity, whereas German teachers placed pressure in work, lack of resources, and disciplinary matters as hindrances (Zhou et al., 2013).

In the U.S., Teachers not only thought creativity can be taught in the classroom, but viewed knowledge about creativity as important for teachers to foster creativity (Aljughaiman & Mowrer-Reynolds, 2005). Furthermore, more than half of teacher participants in their study reported that their school places importance on fostering student creativity and that they employ strategies to foster creativity in their classroom. However, the rate of agreement was decreased when these teachers were asked if developing creativity is the classroom teachers' responsibility. Characteristics of teachers who may foster creativity in the classroom also depend on teachers' beliefs on other factors. Hong, Hartzell, and Greene (2009) found that teachers with sophisticated beliefs about knowledge and with high intrinsic motivation for "creative work" reported supporting student creativity through their instructional practices (e.g., facilitate the development of multiple perspectives, transfer, task commitment, creative skill use), as compared to teachers who have high intrinsic motivation for "challenging work" and performance goals. In addition, teachers in gifted programs reported more sophisticated epistemological beliefs, higher learning-goal orientation, and lower performance-goal orientation than did teachers in general education classrooms (Hong, Greene, & Harzell, 2011). Whether these differences in the two groups of teachers were results of preservice and inservice education or from some other sources are not known at this time.

17.3.2 Children's Conceptions of Creative People and Creativity

There are very few studies that have examined children's general conceptions of creativity that did not focus on particular elements associated with creativity. One study examined gifted adolescents' conceptions, in which they viewed creativity as artistic abilities and motivation, whereas risk-taking and inquisitiveness were identified as important elements of their own creativity (Saunders-Wickes & Ward, 2006). In this section, we present a recent study that examined conceptions of creativity in middle school children.

Participants and Measures

Two middle schools participated. The first school was a private Catholic school and the second school was a public charter school in large southwest metropolitan areas in the U.S. Sixth-grade (30 males and 28 females) and seventh-grade students (25 males and 32 females) from the private school and sixth-graders (34 males and 31 females) of the public charter school participated. About 65% of the participating students of the private school were Caucasian-Americans, 12% Hispanic-Americans, 12% Asian-Americans, and 11% others. Participating students of the public school consisted of 72% Hispanic-Americans, 13% African-Americans, 13% Caucasian-Americans, and 2% others. About half of the students from the participating public school received free or reduced lunch and about 30% of the students had limited language proficiency.

Students were asked to write their perceptions of creativity on a paper, with one item asking "How can you tell someone is creative? Write all you can think of." In addition, a 5-item questionnaire on creativity myths was distributed. The items were: (1) People are born creative or uncreative; (2) People don't have to learn to be creative because creativity just happens; (3) Creativity is about arts like music, painting, and so on, but not about science; (4) Creative people work alone rather than work in groups, and (5) The smarter people are, the more creative they are. Students rated the items on a 4-point Likert scale: (a) = not true at all; (b) = somewhat true; (c) = often true; and (d) = very true. Students read the directions, "The following items ask your views about creativity. Read each item and indicate how you generally think or feel by circling a, b, c, or d. There are no right or wrong answers" and filled out the questionnaire.

Students' narrative responses were analyzed using the following procedure: category elicitation, mapping, revising categories and subcategories elicited, and remapping as necessary. To quantify data, student responses were mapped onto categories and counted. For the 5-item questionnaire data, multivariate and univariate analyses of variance were conducted.

Findings 1: Students' Conceptions of Creative People

Characteristics of creative people described by the sixth- and seventh-graders from the private school were very similar, with slight differences in the order of some characteristics (see Table 17.1). The words used to describe a creative person with six or higher frequencies in both grade levels included: are artistic, have good ideas or are thoughtful, produce original/unique/unusual answers or products, have creative personality (e.g., extrovert, optimistic, open), express/make things, have

Table 17.1 Children's conceptions of creative people by grade

Grade 6		Grade 7	
Original/new/unique/unusual	38	Artistic	80
Artistic	32	Ideas/thoughts/thinkers/thoughtful	41
Ideas/thoughts/thinkers/thoughtful	27	Personality	30
Demonstrate/express/build/make	23	Original/new/unique/unusual	27
Different, multiple ideas	15	Different, multiple ideas	21
Personality	11	Demonstrate/express/build/make	18
Imagination	8	Imagination	9
Resourceful/inventive/improving	6	Intelligent/ability/quick thinker	6
Intelligent/ability/quick thinker	6	Resourceful/inventive/improving	3
Quality of work	4	Quality of work	3
Risk taker	3	Risk taker	3
Skills	2	Skills	3
Emotion into work	2	Emotion into work	3
Elaboration/details	1	Elaboration/details	3
Total responses	178	**Total responses**	250

Note. The first 14 categories of conceptions expressed by students of private school are presented. Sample sizes: Grade 6 = 58; Grade 7 = 57

different/multiple ideas, have imagination, are intelligent, and are resourceful (only 6th graders). Other items with less than 5 counts in both grades included: produce high quality work, are risk-takers, put emotions to work, are detailed, have good skills, have good knowledge, and have hobbies (only 7th graders). Seventh graders expressed a greater number of conceptions than sixth graders, indicating that growing and schooling provide more opportunities to experience creativity and the ability to describe their viewpoints in general.

When themes were compared across the two schools for sixth graders, some significant differences were revealed, although similarities across the schools were still apparent (see Table 17.2). First, when themes with five or more frequencies were examined, there were 7 themes that emerged in the public-school sixth graders, as compared to 9 themes in the private-school sixth graders. Those 7 themes about creative people included: artistic, original/unique/unusual, good ideas/thoughtful, express/make things, personality, and imagination. The two themes that showed only in the private-school sixth graders were: produce different/multiple ideas and are intelligent. When the frequencies for the 14 themes were aggregated, the difference between the two schools was vast, with 95 and 178, for public and private school, respectively. Second, of all elicited themes, 12 themes were mentioned by the public-school sixth graders, with the unmentioned themes including have good skills, are risk-takers, and are detailed.

Students' conceptions of creative people corresponded to those characteristics found in the creativity literature (Feist, 1998; Feist & Barron, 2003), although some creative characteristics were not expressed (e.g., autonomy). The highest responses regarded arts, and none were distinctly about other subject domains, indicating the

Table 17.2 Children's conceptions of creative people by school type

Public charter school		Private catholic school	
Artistic	32	Original/new/unique/unusual	38
Original/new/unique/unusual	12	Artistic	32
Resourceful/inventive/improving	12	Ideas/thoughts/thinkers/thoughtful	27
Demonstrate/express/build/make	12	Demonstrate/express/build/make	23
Ideas/thoughts/thinkers/thoughtful	7	Different, multiple ideas	15
Personality	6	Personality	11
Imagination	5	Imagination	8
Emotion into work	3	Resourceful/inventive/improving	6
Quality of work	3	Intelligent/ability/quick thinker	6
Different, multiple ideas	1	Quality of work	4
Intelligent/ability/quick thinker	1	Risk taker	3
Knowledge	1	Skills	2
Skills	0	Emotion into work	2
Risk taker	0	Elaboration/details	1
Total responses	95	**Total responses**	178

Note. The first 14 categories of conceptions expressed by sixth graders of public and private schools are presented. Sample sizes: Public charter school = 65; Private catholic school = 58

art bias in these students. The school difference in total responses warrants a comment. The sixth-graders of the private school expressed not only more variety of conceptions but in a greater number (about 85 % more) of responses than those of public school. This disparity between the two schools may be associated with socioeconomic status coming from different demographics of the two different types of the schools, likely presenting different life experiences, with children with more means having more opportunities to experience and express creativity.

When students' responses were compared with the five themes of teachers' conceptions that emerged across different studies (minimum six studies), three of the five, imaginative, original/unique, and artistic were mentioned by both students and teachers. The two themes that were mentioned by teachers but not by students were curious/exploratory and intelligent (by sixth graders of one school). There were many characteristics of creative people that teachers mentioned (minimum three studies) that did not emerge in students' themes and were rather conspicuously classroom behavior-related: nonconforming/challenging, independent, always questioning, quick responses, active, wide interests, innovative, confident, and self-centered.

Findings 2: Students' Conceptions of Creativity

When sixth and seventh graders within the private school were compared, significant differences were not demonstrated either at the multivariate, $p > .84$, or univariate results, ps ranging from .25 to .99. The sixth graders of the two different schools demonstrated statistical significances at the multivariate level, $p = .005$, $\eta^2 = .15$, and three of the univariate results (Items 1, 3, and 4), $ps < .02$, with η^2 ranging from .05 to .06.

For Item 1, "people are born creative or uncreative," with the private school sixth graders rating lower ($M = 2.10$; $SD = 0.78$) than those of the public school ($M = 2.52$; $SD = 1.03$). On Item 3, "creativity is about arts like music, painting, and so on, but not about science," a similar pattern was noted, with the private-school students rating lower ($M = 1.72$; $SD = .92$) than the public-school students ($M = 2.19$; $SD = 1.09$). On Item 4, "creative people work alone rather than work in groups," the private-school students again agreed less ($M = 1.80$; $SD = .84$) than those of the public school ($M = 2.25$; $SD = 1.04$). Follow-up interviews with participating students could have helped understand reasons behind these discrepancies, but circumstances did not allow us to gather follow-up data.

The two items that did not show school differences are described here. Regarding Item 2, "people don't have to learn to be creative because creativity just happens," the participating sixth graders from both schools rated high (between somewhat-true and often-true), with mean scores in the private and public school, respectively, $M = 2.65$; $SD = 1.09$, and $M = 2.94$; $SD = 1.23$. Item 5, "The smarter people are, the more creative they are," showed that on average, students rated between not-true-at-all and somewhat-true, with mean scores of the private and public school, respectively, $M = 1.67$; $SD = 0.90$, and $M = 1.71$; $SD = 0.80$.

These findings indicate that students of less affluent families in general were more inclined to agree with creativity myths. Perhaps students of affluent background have more opportunities to develop creativity while they were growing up. Even for those students who might have thought that they were born uncreative or not artistic, the environment in which they were brought up might have helped them experience creative thoughts and behaviors through play or school activities. On the other hand, students of lower socio-economic status may have had less chance to experience creativity-encouraging environments. This speculation should be verified in future studies, especially whether living in poverty or near poverty necessarily deprives students of creativity.

The children's view on intelligence and creativity not being closely related might have come from students' experiences, especially those who may not have achieved highly but see themselves as creative thinkers or as artistic. More students from both the private and public school tended to believe that creativity just happens than not. Although private-school students were less likely to think that people are born either creative or uncreative, they believe more strongly that creativity just happens. This slight contradiction within the private-school students might have been related to reading Big-*C*s and observing young talents on the Internet and TV, causing them to think that learning to be creative is hard to accomplish. These findings highlight the importance of creativity education in schools.

17.4 Contradictions: Understanding and Incorporating in Classroom Instruction

Creativity and innovation have become the first and most important construct in the business sector. Breen (2004) states that hardly any mission statements of business organizations do not herald creativity. In educational research, although continued efforts have been made to conduct scientific studies of creativity and its educational and psychological correlates (e.g., Amabile, 1996; Cropley, 2006; Hong, Peng, & O'Neil, 2014; Marziyeh, Ejei, Hejazi, & Tabatabaee, 2014), educational research on creativity seems to have been tangential to classroom applications, and schools have been very slow to incorporate creativity in teaching and learning. Of the various reasons, the conceptions of teachers and children still remain as one of the most influential factors facilitating or impeding the incorporation of creativity in classroom instruction. Based on the literatures we reviewed on teachers' conceptions of creativity and the findings on children's conceptions, we discuss contradictions between conceptions and practices and offer some suggestions for classroom applications where possible.

17.4.1 Yes, Developing Creativity in Students Is Important, But No, Not My Priority

Many teachers believe that cultivating creativity in students is important, children can be taught to develop creativity in the classroom, and teachers should increase knowledge about creativity. However, some of these teachers also think that developing student creativity is not their responsibility (Aljughaiman & Mowrer-Reynolds, 2005). In the present dominant educational environment, teachers are overwhelmed with other pressing responsibilities such as content coverage for high-stakes tests and do not think that there is enough class time for students to explore and enhance creativity (e.g., Crow, 2008; Hong & Kang, 2010; Kampylis, Berki, & Saariluoma, 2009). Understanding this problem, creativity scholars have written some how-to literatures, although not for all subject domains. These literatures can support teachers to not only foster student creativity but also fulfill curricular standards by integrating creativity into the curriculum so students can increase both creative-thinking ability and academic achievement (e.g., Baer & Garrett, 2010; Beghetto, 2009; Beghetto & Kaufman, 2010a, 2010b; Fairweather & Cramond, 2010).

Note, however, that other studies portray a somewhat different version of the realities faced by teachers. Almost all teachers in Greece who participated in the Kampylis et al. (2009) study agreed that fostering student creativity is a teacher's responsibility. The difficulty here is teachers' competency, as only about 20% thought that they were trained for facilitating student creativity. Some teachers in

Li's (2006) study also thought that they were not qualified enough to foster students' creativity on their own. Hoping for teachers to be motivated enough to learn more about creativity by themselves in this not-enough-class-time situation is not realistic. Integrating creativity in classroom instruction requires robust teacher education presence and professional development support for teachers. However, information is not available on the extent to which teacher education programs offer creativity-related courses and the quality of courses, if offered.

17.4.2 I May Do It If Things Are Ready for Me

Due to the recent recognition of the importance of creativity, many countries have issued policy documents underscoring the importance of creativity in education and addressing instructional possibilities to increase creative ability (Shaheen, 2010; Thompson, 2009). There has been an increasing emphasis on developing creativity-driven curriculum (Choe, 2006; Zhu & Zhang, 2008) and teachers are expected to follow the implicit and explicit demands contained in new policies (Yeh et al., 2004). Whereas new curriculum focuses on student-centered experiences for fostering creativity as an important goal in education, there is little substance as to guidelines or curricula materials that teachers can use for practical application, and pedagogy on fostering creativity are left to teachers' discretion (Hong & Kang, 2010; Park, 2013). Moreover, most current teachers have not had any formal training on creativity during their teacher-education program or inservice professional development (Bolden et al., 2010; Cheung & Mok, 2013; Newton & Newton, 2009a, 2009b), thus teachers feel that they are not equipped to teach for creativity. Even when professional development is available, the opportunities are rare and inadequate (Park et al., 2006). That is, although there may be plenty of rhetoric about creativity, little substantive action is found at present.

Classroom teachers will not be able to help students increase creative-thinking ability when they do not know what creativity means in the subjects they teach and when well-designed materials and activities to utilize for teaching and assessment of creativity are not readily available. Related to the first issue, Not My Priority, the same provisions regarding how-to literatures and substantial professional development opportunities are required.

17.4.3 I Am Almost There, But They Are Not

A dilemma and tension generated by the mix of a high level of knowledge about creativity and environmental inadequacy was described by Chien and Hui (2010) in their descriptions of early childhood teachers' conceptions. Taiwanese teachers, who were more knowledgeable about factors affecting creative performance than other groups of teachers from Hong Kong and Shanghai, chose teaching method and curriculum design as the most important factors for implementing creativity instruction. The presence of less conducive environment and other barriers for facilitating creativity in students were more visible to Taiwanese teachers due to high expectations based on their knowledge and professionalism, creating a dilemma for these teachers. The clash that these teachers felt, as frustrating as it sounds for them, in fact, was intriguing and rather hopeful as these teachers seemed rather well educated for creativity instruction. Having awareness of the environmental inadequacy may trigger them to seek solutions.

17.4.4 Creativity Is Art

Although creativity means more than arts for most teachers, many teachers relate creativity with artistic and literary endeavors (e.g., Aljughaiman & Mowrer-Reynolds, 2005). For these teachers it is the art instructor's responsibility for enhancing creative abilities, and they may not underscore creative processes and creative outcomes in domains they teach. Those teachers who hold the view that creativity manifests in various domains may put forth efforts to foster creativity in their regular classroom teaching. The flip side of this view is that teachers' awareness of the multi-domain nature of creativity, especially for kindergarten and primary teachers, may engender teachers' feeling of incompetence and skepticism concerning their ability to foster creativity in children (Kampylis et al., 2009). This issue again brings up the question of adequate materials and activities for creativity instruction in various subject areas.

17.4.5 Amicable Trait, But Not in My Class

Some teachers know that certain traits are related to creativity, some even report that they enjoy working with creative students, but they think that some of those traits are not desirable in the classroom. Often, personality characteristics of teachers' favorite students were inversely related to creativity, and some teachers tend to discourage certain behaviors that are related to creativity traits (Runco & Johnson, 2002; Westby & Dawson, 1995). Whereas some teachers are not aware of behaviors related to creativity, other teachers think uncreative behaviors such as conforming are creative, and these behaviors often desired by classroom teachers (Runco & Johnson, 2002).

The discrepancies in creativity conceptions between children and teachers reported earlier deserve attention. Whereas some views of creativity, such as imaginative, original, and artistic, were overlapping across students and teachers, a large number of teachers' conceptions about creative children were not indicated in students' conceptions. Teachers' views such as nonconforming/challenging, always questioning, quick responses, active, wide interests, innovative, confident, and self-centered, present a tinge of negativity and appear contradictory to students' views in which they did not see creativity in such a light. As teachers' personal beliefs about creativity and creative traits will be applied when judging children's behaviors in the classroom, it is important that the research findings on creativity reach practicing teachers.

17.4.6 Not in Our Culture

Recent emphasis on creativity education is ubiquitous across nations. However, in some areas of the world, barriers for creativity education seem more culturally bound. In mainland China, for example, early childhood educators are expected to develop teaching competencies in creativity and promote learning of creativity in classrooms (Chien & Hui, 2010). However, Chinese culture may lack a supportive environment for teachers to explore new methods in the classroom. In the traditional classroom culture, students are expected to obey the teacher's authority. Deviations from this expectation may be viewed as signs of disrespect or rebelliousness. Thus, implementing creative teaching and teaching for creativity may be challenging to teachers in these cultures (Cheng, 2004; Ng & Smith, 2004).

Sternberg (2007) found that Eastern cultures consider contributions to society and the ethicality of creativity as important elements for creative work. When creativity was used for an unethical purpose, some teachers (Hong & Kang, 2010) denied that creativity was present, with the denial four times more likely in Korean teachers as compared to the U.S. teachers who had the tendency to separate ethicality from creativity. How should educators process this aspect? Kaufman, Cropley, Chiera, and White (in press) found that Western people, the U.S. in their study, view morally ambiguous acts as more creative. We recommend work by Cropley, Kaufman, White, and Chiera (2014) and Kaufman's (2009) chapter on "Does creativity have a dark side?" that shed light on this important element of creativity.

One caveat regarding cultural difference in conceptions and practices associated with creativity needs to be discussed here. It is noticed in literatures that when findings on cultural impact cannot be cleanly interpreted, authors tend to rely on outdated interpretations that might have been applicable sometime in the past. For instance, teaching for creativity is considered incompatible with the traditional Asian cultural value of social contribution and the prejudice against individuality (Kwang & Smith, 2004; Rudowicz, 2004; Rudowicz & Yue, 2000). Admittedly, there may be some teachers thinking in this fashion even now, but the train seems to have departed to meet the newer world some time ago (our best guess is one to two decades) and most teachers as well as students are riding on that train. In other words, great cultural shifts are taking place alongside changes in educational policy and practices. Although the value of social contributions to creativity should not be diminished in any cultural context, such a value does not need to rule out the value of individuality in the development of social and cultural capacities for addressing challenges of the modern world. As we have no hard data to support our discussion but are writing based on anecdotal information (observations and informal interviews and discussion), this is an important topic for future research in education, psychology, and sociology.

17.4.7 Anyone Can Be Creative; Sounds Good, But Really?

To most laypeople, unless otherwise educated, creativity means innate ability or eminence. Classroom teachers are not exceptions to this understanding. The good news is that although there are teachers who think only a few can be creative, teachers in general hold the view that most students can be creative (Hong & Kang, 2010). The rather old-by-now topic about the relation between creativity and intelligence gives some clue as to teachers' conceptions regarding who can be creative. Preservice teachers' views that anyone can be creative was contradicted by their beliefs that intelligence is a requisite trait for creativity (Seng et al., 2008). Some researchers indicate that although weak to moderate association between creativity and intelligence has been evidenced to a certain level of intelligence, high intelligence does not necessarily enhance creativity (e.g., Baer & Kaufman, 2005; Hong & Milgram, 1996; Walberg & Herbig, 1991).

The creativity-achievement relation also sheds light on the issue of anyone-can-be-creative. Although some teachers, seeing low-achieving students manifesting creativity, believe that anyone could be creative, other teachers think that only high-achieving students are creative; fortunately, many teachers have observed the inconsistent relation between achievement and creativity (Hong & Kang, 2010; Park, 2013; Zhou et al., 2013). A related topic is the relation of knowledge to creativity. Creativity is not a knowledge-free skill (Craft, 2002). In a study by Diakidoy and Kanari (1999), the majority of preservice teachers thought that creative outcomes rely on knowledge. Contradictorily, however, only about a quarter of the same research participants thought that students' creativity will be manifested when students have relevant knowledge, showing their uncertainty in understanding the relation between knowledge and creativity.

17.4.8 Assessment of Creativity? I Have No Clue

If educators in the trenches were encouraged or required to implement creativity instruction in their practices, another important element needed for this implementation will be to make available instruments to assess creativity. The assessment of creativity is rather difficult as compared to that of standardized tests for which correct answers are predetermined. Imagine a mathematics teacher, who tried to increase creative-thinking in mathematical problem-solving, but then applies conventional criteria to assess creative solutions to mathematical problems.

Domain generality and specificity in creativity have a close relation with the measurement of creativity (Baer, 2003; Hong, 2013; Plucker, 1998). As creative outcomes are manifested in various domains such as science, music, and so on, one might think that the domain issue may not be applicable for assessment of creativity. However, data from the measures used for domain-general creative-thinking ability (i.e., generating original and divergent ideas in many domains) produced predictive-validity evidences with creative behavior in the real world as criterion (e.g., Cramond, Matthews-Morgan, Bandalos, & Zuo, 2005; Hong, Milgram, & Whiston, 1993; Torrance, 1993). A strong association between domain-general and domain-specific creative-thinking ability was found in various age levels, gender, ethnicity, and learning disabilities status, but different life experiences afforded by schooling, gender, and culture had stronger impacts on domain-specific creative thinking (Hong & Milgram, 2010). These studies indicate that measures for both domain-specific and domain-general creativity have contributions to make in assessing students' creativity in the classroom.

Beyond the divergent-thinking measures that have been widely used (e.g., Jellen & Urban, 1986; Torrance, 1974, 1999), there are various measures for creative personality, attitude, motivation, and activities, including from biographical information, inventories,, nominations, product ratings, self-reports, to biological methods such as functional magnetic resonance imaging (fMRI) or quantitative electroencephalogram (qEEG), which are beyond the scope of this chapter.

On the domain-specific creativity side, measures used in research studies include creating mathematical word problems, story-telling, writing poetry or short stories, making collages, musical compositions, and everyday problems (Baer, 1996, 1998; Han, 2003; Hickey, 2001; Hong, Peng, O'Neil, & Wu, 2013; Reiter-Palmon, Illies, Cross, Buboltz, & Nimps, 2009). Self-report assessment of creative activities and accomplishments (e.g., Carson, Peterson, & Higgins, 2005; Hong & Milgram, 2009) are also relevant for classroom use. Another useful measure that classroom teachers may adopt is *Creative Real Life Problem Solving* (CRLPS) (Hong, 2013). Each CRLPS measure represents a particular topic/context, involving real-life problems to solve. That is, each item describes a problem situation that arises in a specific life situation. When the problem-solving items are being developed for students, students' life situations are described in scenarios that could occur in their lives. Each student should be able to imagine him- or herself in the scenario while solving the problem. Students are asked to generate as many or unique solutions as they can to each real-life problem presented to them. That is, CRLPS can be created by any classroom teacher interested in assessing creative-thinking ability in their students. Scoring CRLPS responses are similar to those for divergent thinking tests, or expert judges (e.g., classroom teachers) can assess the quality and quantity of the responses.

17.5 Summaries, Recommendations, and Thinking Forward

There seem to be a few important contradictions surrounding creativity conceptions that educators may find valuable for practical uses. As implicit conceptions of creativity play an important role in teaching practices, they should be addressed to help teachers check their assumptions and misconceptions. We summarize contradictions between creativity conceptions and classroom practices discussed earlier:

(a) Most teachers think that developing student creativity is important, but they also think that it is not their priority.
(b) Teachers may engage in classroom implementations of creativity instruction but only when curricula and instructional materials are readily available for them.
(c) Even for those teachers who are ready for classroom implementation of creative education, barriers for facilitating creativity prevents them from moving forward.
(d) Many teachers relate creativity with artistic and literary endeavors, thus relegating creative education to art or literature instructors.
(e) Some teachers think that creativity traits are not desirable in the classroom and view creative children unfavorably.
(f) Cultural and societal differences in teachers' views about creativity need to be understood for proper implementation of creativity instructions.
(g) Although research literatures indicate that most teachers believe that students can be creative, when their views on the relations of creativity with intelligence, with achievement, and with knowledge are taken into account, the "anyone can be creative" view does not seem to hold.
(h) Assessment of creativity needs to be addressed before teachers are requested to facilitate creativity in the classroom.

Beyond the need for monitoring their own personal beliefs, it is important that teachers acquire robust content and pedagogical knowledge of creativity to incorporate creativity into their classroom instruction. Indeed, all items discussed in the contradiction section point to the need of substantive professional development. As reviewed above, numerous articles, presenting various predicaments in creativity education, call for teacher training not only during teacher education programs, but also through ongoing professional development, including workshops, seminars, and other forms (Aljughaiman & Mowrer-Reynolds, 2005; Cheung & Mok, 2013; Cheung & Leung, 2013; Chien & Hui, 2010; Newton & Newton, 2009a, 2009b; Park et al., 2006). Many countries have put forward policies encouraging or requiring inclusion of creativity in education. However, unless it is practiced in schools, it will remain a hollow gesture. There has been a modicum of signs that creativity training has worked somewhat (Bolden et al., 2010; Cheng, 2011; Panaoura & Panaoura, 2014), albeit authors of these studies strongly expressed the need for further teacher training.

We offer a few items for professional development that may help teachers prepare for fostering creativity in students:

(a) Provide opportunities to increase awareness of personal beliefs by making them explicit so that they are open to personal challenge and reflection, pointing to contradictions between implicit beliefs and formal knowledge.
(b) Provide various examples, materials, strategies, activities, and opportunities to instantiate their knowledge in the classroom during and after teacher education.
(c) Utilize mini-*c* concepts when preparing materials and activities with which students can have experiences of producing novel and personally and interpersonally meaningful interpretations of experiences, and curtail habitual neglecting of unexpected moments of emerging creativity in the classroom.
(d) Provide various kinds and types of problems and "explicit instruction" for creative responses, so students can be motivated to produce more creative ideas and products.
(e) Help teachers understand classroom-environment elements that stimulate or impede the development of creativity.
(f) Share with teachers various correlates of creativity to help them get interested and remain open to reading more literatures to increase their knowledge about creativity (Amabile, 1996; Baas, Koch, Nijstad, & De Dreu, 2015; Beghetto, 2009; Beghetto & Kaufman, 2007, 2009; Eckhoff & Urbach, 2008; Chan, 2005; Hong, O'Neil, & Peng, in press; Kaufman, 2006; Marziyeh et al., 2014; Rietzschel, Nijstad, & Stroebe, 2014; Runco, 1996, 2003; Vygotsky, 1967/2004).

The discrepancies found in students of public and private schools warrant consideration. Although demographic factors such as socioeconomic status, gender, and so on, in their relations with creativity were not highlighted in this chapter, creativity education would require understandings of these phenomena. Students' views on creativity myths were more strongly aligned with the item, "creativity just happens; people do not need to learn creativity because it just happens," followed by "people are born creative or uncreative." Surprising or not, some children in the twenty-first century still believe in these myths. Understanding children's conceptions of creativity can help teachers prepare to tackle these issues, especially with beliefs on these two items, as they can impede students' receptivity to creativity instruction.

Educational systems should invest in the identification and development of creative potential and develop institutional cultures where investment in educating creative minds is recognized as beneficial to society in the long-term and to the wellness of individuals by enabling them to lead more satisfying lives. We need to develop a culture where creativity and creative thinking is highly valued and acknowledged as a critical resource for human advancement. How researchers and teacher educators make literatures on creativity available for professional development will make a large difference in the implementation of creativity instruction in schools. Otherwise, creativity myths and contradictions will remain unresolved and will continue to implicitly contribute to the consignment of some students to roles associated with enriching and advancing humanity and others to roles associated with rote behaviors and unsatisfying adulthoods.

It is important to be reminded that this chapter addresses what the field of creativity understands today. Conceptions of creativity change as sociocultural environments change perhaps based on the combination of tradition, ideology, wealth, and orientation towards globalization. For instance, technology, the Internet, and social media and their relations to creativity emerged as relevant topics for consideration only recently (Hong & Ditzler, 2013; Peppler & Solomou, 2011). This development may help expand and enhance the sharing and promoting of creativity with virtual communities, including training through the Internet, allowing needed information to reach many practitioners in an efficient manner (Al-Balushi & Al-Abdali, 2015). Although the online environment will create additional challenges, we hope in the end that it will help more individuals and groups actualize their potential. Creativity researchers have put forth significant efforts in producing new knowledge on creativity. However, when it comes to the effects of new knowledge produced by scholars on classroom instruction, it is a woefully inadequate record. We advocate that practitioners be encouraged and recruited for producing practice-based research evidence on creativity and share their work through the Internet (Rowell & Hong, in press). This effort will increase not only knowledge base of what-works in specific contexts in which practitioners best understand the problems and challenges, but is an excellent way to democratize knowledge related to strengthening the place of creativity in educational systems.

Finally, the teachers' conceptions of creativity and creative children described in this chapter are based on the close scrutiny of published literatures. Although we were careful about matching research questions presented by the original researchers, the research contexts of and measures used in the research studies were not identical. It is recommended that readers exercise caution in interpreting findings and utilize references where warranted. Children's conceptions of creativity has rarely been studied, thus we relied on one empirical study conducted by the senior author of this chapter. More research studies with children, as well as teachers, are needed to understand their conceptions now and in the future to determine whether creativity instruction and societal/cultural changes make differences in improving the understanding of creativity.

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Chapter 18
On the Measurement and Mismeasurement of Creativity

Todd Lubart and Maud Besançon

Abstract Creativity is a 21st-century skill that is receiving increasing attention in schools. One of the key issues that needs to be solved to facilitate the education of creativity is its' measurement. There is however ongoing controversy on the measurement of creativity. This is an issue of debate concerning both children, adolescents' and adults' creativity. A growing scholarly literature, since the earliest attempts to measure creativity more than a century ago, has not yet resolved this issue. To mention just a few of questions that remain to be resolved, we can cite:

1. What is creativity?
2. Why measure it?
3. How can creativity be measured?
4. Who is the best judge of creative work?

These questions will be examined in this chapter and a new tool for the evaluation of creative potential in educational settings will be described.

18.1 Introduction

The three R's—Reading wRiting, and aRithmetic—are being replaced by the 4 C's—Critical thinking, Collaboration, Communication, and Creativity (Trilling & Fadel, 2009; Partnership for 21st Century Skills, 2015; De Fruyt, Wille, & John,

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2015). However, several of these twenty-first century skills have not yet received much attention at school (OECD, 2016). In particular, this is true for creativity (Craft, 2005; Piirto, 2011). One of the key issues that needs to be solved to facilitate the education of creativity is its' measurement. There is however ongoing controversy on the measurement of creativity. This is an issue of debate concerning both children, adolescents' and adults' creativity. A growing scholarly literature, since the earliest attempts to measure creativity more than a century ago, has not yet resolved this issue. To mention just a few of questions that remain to be resolved, we can cite:

1. What is creativity?
2. Why measure it?
3. How can creativity be measured?
4. Who is the best judge of creative work?

In this chapter, we will attempt to describe the essential nature of the debate on each of these questions, and to provide our own perspective, developed based on our experiences in research and field settings. As the topic is vast, we will focus on the measurement of creativity in children and adolescents.

18.2 What Is Creativity?

Although there are more than a hundred various definitions of creativity circulating in the literature, they bear a certain family resemblance (Amabile, 1983; Baer, 1993; Mayer, 1999; Sternberg, 1999). First, there is always some notion of novelty, originality or uniqueness. This novelty may be characterized as intra-individual (novel for me), inter-individual in a local social setting (novel compared to my peers), inter-individual in a macro-social setting (novel with respect to my larger social unit), inter-individual in a historical and macro social setting (novel with respect to previous generations in my social context, and outside my social context – for all mankind). This conception echoes recent work on mini-« c », little-« c », pro « c », and big « c » creativity (Beghetto, 2010; Kaufman & Beghetto, 2009). Second, there is always some notion of value, utility, usefulness, or meaningfulness of the novel contribution. This « value » is appreciated again at different intra- and inter-individual levels, just like the novelty of the production. Also, in order to complicate things, it is not necessary that the same exact meaning or criteria for value be used at each level (Lubart, Mouchiroud, Tordjman, & Zenasni, 2015). Third, there is often some notion of authenticity which reflects the intentionality to create, personal engagement in the process of creation, and relative meaningful, purposeful nature of the creative process (Kharkhurin, 2014; Newman & Bloom, 2012). This third component of creativity has received various degrees of attention and is often considered when creative work is distinguished from « random » events that can also produce novel, useful outcomes. Given the range of intra- and inter-individual contexts in which the criteria of novelty, value and authenticity can be appreciated, it is not surprising that there is disagreement on the « right » level of analysis. Should novelty be measured against an individual's previous accomplishments, or against peer-referenced work produced typically by other children of the same age or school level? (Kaufman & Baer, 2012). This decision will have an important impact of the way that creativity is measured, leading some authors who hold an alternative point of view to claim that creativity was in fact mismeasured.

18.3 Why Measure Creativity?

As highlighted by Runco and Chand (1994), the term "evaluation" contains the word "valuation", and the act of measuring an entity makes it more tangible, objectified and increases its "value". Indeed, creativity may be measured with respect to several different objectives. Consider four examples.

18.3.1 Identify an Individual's Potential to Offer Relevant Opportunities

The objective is often advanced to optimize the match between individuals and educational opportunities, taking the "best" students who will benefit fully from some type of school program. For example, an art school may consider a test of artistic creation during a competition for admission and select the candidates showing the greatest creative abilities. These candidates will benefit from the educational program and will have a greater likelihood of success in the professional field. So in this context, the evaluation is intended to provide helpful information in a search process, benefitting both the candidate and the school. Of course, if the number of students is limited in some special programs, measurement tools are needed for selective procedures.

18.3.2 Identify the Level of an Individual or Group and Follow Development Over Time

The objective is to understand the natural changes related to the development of children's and adolescents' creativity and then propose creative thinking stimulus programs tailored to developmental characteristics of each child and adolescent.

18.3.3 Identify the Level of an Individual or Group in Order to Observe the Impact of a Specific Educational Program

This approach, essential to educational curriculum development, requires measuring the capacity on which education bears. If creativity is assumed to grow, we need tools to measure the level of creative capacity before and after the educational intervention. Often, educators want to examine the effectiveness of exercises or experiences at school.

18.3.4 Identify the Collective Level of a Class, a School or a Larger Group of Individuals

Here the main objective is to compare a group to other groups. The target is to answer questions such as: "are students in United States more or less creative than students in France?" "How do students in public school compare to those in private schools?". It is therefore associated with a "ranking" process which can be conducted at the regional, national or even international level. Benchmarking, allocating limited resources and trying to improve educational programs through comparisons between different populations are some of the ultimate uses of this kind of information.

These different goals tend, at least partially, to lead to contrasting approaches to creativity assessment tools and procedures. For example, to identify the individual creative potential (the first case), the tools used should identify the various important elements of creative potential in a domain, characteristics on which individuals show strong variability and which predict later success in training and career performance. Thus, for example for an engineering school, the particular characteristics of creative engineers will be important to measure, such as mental flexibility using population norm-referenced tests.

In contrast, if the objective is to identify the personalized nature of creative potential of individuals and then offer exercises to stimulate their creative potential within a person-centered approach (the second case), it is more interesting to examine where an individual is in his or her own sequence of creative thinking and what is the next possible step in his or her zone of proximal development. In this case, a more qualitative, perhaps process-observational measure of creative thinking will be preferred. Thus, depending on the measurement goal and the way that the creativity scores will be used, different measures will be relevant. This "relativity" in the choice of measurement tools may be a source of debate and controversy.

18.4 How Can Creativity Be Measured

As we have previously seen, the definition of creativity is not always consensual and the measurement goals are not always the same. Moreover, we will argue in this part that a multitude of tools and assessment methods exist. These different tools are a source of controversy because they represent two main types of measures, which are not always distinguished clearly in educational settings. Some focus on *creative potential* whereas others focus on *creative achievement*.

18.4.1 Creative Potential

Creative potential refers to what an individual can do given his or her cognitive abilities, personality, motivation and environment. The potential may change over time. A child with a high potential at a time “t” in his/her development may no longer have the same potential some years later. Imagine a child who is interested at one point in a scientific topic and reads many related articles. His or her knowledge offers the potential to invent new ideas on this theme. If, subsequently, the child is no longer interested in this subject for several years, he or she will forget the readings and the scientific field will continue to evolve; the child who is now older will not necessarily have the same creative potential on this theme or in this particular domain.

Creative potential is not necessarily a general potential which signifies the same level of creative ability in all areas of action: a high potential in literary creativity, for example, is not always associated with the same level of potential in creativity scientific or musical fields (Lubart & Guignard, 2004). Lubart and Sternberg (1995) conducted a study in which people made drawings, invented stories, suggested publicity ideas and solved scientific problems. A panel of qualified judges then noted productions in terms of creativity. The correlations between the ratings were positive but weak to moderate, indicating that there are certain similarities between the performance of tasks, but also some specificities. It is appropriate in this case to measure creative potential in various production fields (art-graphic, literary, scientific, musical, etc.), rather than measuring the overall creativity of all fields. The low positive correlations are explained by the involvement of certain psychological characteristics in one kind of production but not in another due to sets of rather specific characteristics for each task.

To understand the nature of creative potential, it is also important to note that potential does not necessarily lead to creative achievements (Gagné, 2004). Potential refers to a latent capacity, expressed when engaging in a task. However, an individual will not necessarily engage in a task and thus may never express his or her potential. Examples of different measures of creative potential will be presented in a subsequent part of this chapter.

18.4.2 Creative Achievement

Creative achievement refers to productions made in real-life contexts such as the home, school, and community. These productions may be the result of a spontaneous act or a response to a solicitation of the outside world. When a child makes a drawing for fun, this is an achievement in the context of spontaneous production. When the child makes a drawing for a class assignment in art, it is an accomplishment following a request. When a child makes a drawing in the context of a competition, it is also an achievement. These productions will be, of course, more or less creative; creativity in terms of achievements is valued socially, with appropriate people in the context such as parents, peers, teachers or judges of a competition evaluating the work produced.

In practice, there are three main types of creative achievement measures.

- First, individuals can report their achievements in their various activity contexts using a self-assessment questionnaire. Milgram and Hong (1994) proposed a creative fulfillment questionnaire to children and adolescents. Richards, Kinney, Benet, and Merzel (1988) proposed a questionnaire (Lifetime Creativity Scale) for adults in which the individual notes and describes his or her achievements in professional and non-professional context.
- Second, individuals may be asked to submit a portfolio of work in a given discipline. This type of measurement is often used in artistic or literary fields. There is an evaluation by a teacher, an expert, a jury of a body of work. Sometimes creativity measurement focuses on the behavior of a child seen by his or her teacher (or behaviors observed by an adult in a non-school context). An illustration of such measures is the use of creativity evaluation form developed by Torrance (1976) for teachers. In general, students designated as creative have demonstrated the most original productions, flexible and elaborate productions, compared to other students.
- Third, there is the evaluation of creative accomplishment in a competition. All individuals complete a single task and a jury selects the best productions. Among the most known competitions, there are those of science and technology such as the "Westinghouse Science Talent Search." In this type of competition, individuals (or teams per school) present their inventions and a panel of experts judge the quality of productions. Subotnik and Steiner (1994) studied the creative achievements in the professional fields of science, technology and medicine of a group of winners who participated in the Westinghouse Competition in 1983 and show a good predictive validity in the 12 years following the competition. There are many other competitions in which young authors, composers, visual artists, among others, present their work to a jury.

It is clear that choosing to focus on creative potential or creative achievement is an important decision when measuring creativity. In the next section, we will look in more detail at measures of creative potential.

18.4.3 Evaluation of Creative Potential

When it comes to estimating the creative potential in children and adolescents, there are two main approaches.

- In a first approach, the cognitive, conative, emotional and environmental components or resources for creativity are assessed directly. These components can be considered the "ingredients" of creativity in its various manifestations. For each area and for each task it is possible to weigh the importance of these ingredients and estimate the potential to be creative.
- In a second approach, the measure focuses more on the creative process. The child is asked to engage in creative work by an explicit request in a test situation. This is a measure of potential rather than achievement because the situation is not a naturally occurring event. The task prompts artificially an individual to show what he or she can do. During this task performance, the component capacities or ingredients for creativity will be brought into play. This is ultimately a "simulation" exercise approach. A child is put in a situation and his or her reaction is observed.

Now we will consider in more detail each of these avenues to measure creative potential.

18.4.3.1 Componential Measures

The objective of componential measures is to target different psychological components constituting the creative potential and capture individual differences on these components. This approach allows specific aspects of creativity in a field and in a task to be isolated. However, given the large number of components that are involved in creativity, it is not really possible to measure all in children. This would require a significant number of different measures. Also, ideally, these components measures should be adapted to the field of creative activity; thus, to measure analogical thinking, for example, it should be done in the visual-graphic field or in the verbal-linguistic field.

Componential measures cover both cognitive and conative variables. For example, there are numerous information processing capacity measures for creativity such as insight problems in which the individual is led to focus attention on certain aspects of a problem, reformulate or relax some constraints and then show flexible thinking. For example, when faced with the well-known 9-dot problem, some people remain stuck on the overall shape of the dots (a square) and fail to go outside the square shape to find the way to solve the problem. Numerous conative measures of personality traits and motivational variables important for creativity have also been developed. For example, openness to new ideas has been the subject of several studies (such as Feist, 1998; Batey & Furnham, 2006). This personality trait may be measured by questionnaires for self-evaluation and hetero-evaluation (a child is described by his family or his teachers). In these questionnaires, the typical behaviors of a person who demonstrates openness are described and an individual indicates the degree of correspondence in relation to this description. For example, a person open to new ideas may like to try a new dish or a movie that is not in the movie style she usually chooses. Other measures of different aspects of creative styles or motivation for creativity also exist, such as the scale of creative motivation (Torrance, 1987) in which the child can describe, in self-assessment, the force with which he or she engages in creative activity. In this category of measures, we can mention the questionnaire "What kind of person are you?", proposed by Torrance and Khatena (1970), or Creative Thinking Styles, by Wechsler (2006) and Wechsler & Vendramini (2012). In these instruments, the child describes him/herself with the features, styles and behavioral preferences usually related to creativity. It is also possible to solicit from a child's teacher or parental evaluations of these personality and motivation-related characteristics or even cognitive abilities.

18.4.3.2 Simulation

The objective of the simulation exercise is to assess the creative potential in production situations resembling the actual contexts in which the child can act. This is like soliciting creative work in a "simulator". By analogy to candidates for piloting an airplane, it is possible to get an idea of their potential in a flight simulator. Thus the idea is to put the individual in the skin, for example, of an artist, a writer or composer, and see what he or she can do. This brings into play the cognitive, and conative components. In addition, the creative process that unfolds over time is also engaged. It is interesting to see the outcome of the components implemented during the "simulated" creation process. In the creative process, it is possible to distinguish two phases, which continually intertwine in any complex production: first, the phase of divergence and exploration, and second, the phase of convergence and integration or synthesis.

Divergent-Exploratory Thinking

Based on Guilford (1950), divergent thinking is widely recognized as essential for creativity. This engages thinking in different directions to explore opportunities, to extend thinking "out of the box", outside the natural limits a problem or task has in its initial formulation. This phase is expansive, it leads the individual in new directions. Multiple components are involved in this phase, such as flexibility, openness, perseverance, curiosity and desire to explore a theme. It is also noteworthy that a rich knowledge base and a rich environment facilitate divergence.

Torrance developed a vast research program on the creative skills of children, adolescents and adults. The program had several objectives and led to the well-known battery of tests called the *Torrance Tests of Creative Thinking* (Torrance, 1976). The proposed tests assess the individual's ability to produce many ideas from a single starting point, in a limited time. This starting point can be a hypothetical situation (e.g., the task requires posing many questions about the situation) or a graphic stimulus (e.g., finish incomplete circles by offering original designs) or an object-based stimulus (for example, suggest various solutions to improve a toy). The tests are then grouped into two dimensions, verbal and graphic. Quantitative indices can account for individual differences in the production of divergent thinking. Fluency is the number of ideas, flexibility refers to the number of categories in which ideas can be classified, and originality refers to the relative statistical rarity of each proposed idea in comparison with a reference population. The three indices (fluency, flexibility and originality) are often highly correlated. Longitudinal studies (Torrance, 1972, 1980; Plucker, 1999) show that the TTCT scores of a sample of children predict moderately ($r = 0.30$ approximately) their subsequent creative achievements (up to 25 years later). There are numerous other divergent thinking tasks, and this kind of task has lately dominated creativity measurement, to the extent that some confusion has arisen. Sometimes divergent thinking tasks are taken to be the complete measure of creativity itself, which has led to debate and further controversies.

Convergent-Integrative Thinking

Complementary to the process of divergence and exploration, there is an alternate process which involves evaluating, selecting, combining and integrating different elements or idea fragments. The development of a unique idea is the result of this action. For this reason, it is appropriate to speak of convergence. For convergent thinking-integrative thinking, several components such as the ability to use analogy and metaphor, combinatorial capacity, motivation for the need for achievement, tolerance for ambiguity, and risk taking are involved.

This convergent-integrative kind of thinking has also been the subject of creativity measures. The *Test of Creative Thinking-Drawing Production* (Urban & Jellen, 1996, TCT-DP) is a good example. Under the TCT-DP, participants must make a graphic production from six elements already present on a sheet (five being provided in a graphic frame). Some people develop small drawings for each graphic element (the graphic element in the shape of "S" becomes a snake-shaped element, the semicircle becomes the sun, etc.), others draw a scene and incorporate several elements or all of the graphic elements provided, and finally some people propose drawing a complex shape that embraces and integrates the graphic elements in a set (such as, for example, a face or body of an animal). This type of standardized task simulates an aspect of real creative work and involves the ability to bring together several ideas, and synthesize them, to achieve a single production, including constraints or imposed elements.

In the literature, there are several other tasks focusing on convergent –integrative thinking. For example, Amabile and Gitomer (1984) used a collage task in which children must combine various artistic materials (different colored papers, stickers, etc.) to produce an original work. This collage task by nature focuses on the synthesis of different visual elements provided.

Measures of creative potential tend to focus on either divergent-exploratory thinking or convergent-integrative thinking, but not both aspects simultaneously. It is also important to note that the tools developed during the last 50 years tend to measure creativity only in certain areas of activity (such as the graphic field) or to measure creativity as a general ability. However, correlations between different creativity measures in different domains are positive but weak. So, it seems useful to design and measure the creative potential taking the field or domain of expression into account. Thus, a measurement approach to creative potential by activity sector (graphic field, literary, etc.), which covers both divergent-exploratory and convergent-integrative thinking seems the most appropriate.

A New Approach to Measurement: The EPoC Battery – Evaluation of Potential Creativity

Based on the previously mentioned issues, the battery entitled *Evaluation of Creative Potential* (EPoC Lubart, Besançon and Barbot, 2011) was designed to combine several kinds of tasks that measure creative potential. This tool allows both divergent- exploratory thinking and convergent- integrative thinking to be assessed. The measures were developed first in two application domains, verbal and graphic. Currently, we have extended them to social, math, science, musical and kinesthetic domains. Two forms are available (form A and form B) to allow two successive evaluations with similar tasks. For each form, the assessment takes place in two sessions, spaced about a week apart. Each session has a duration of 15–20 min per domain, depending on the child.

Consider now the various tests proposed. The divergent-exploratory thinking tasks focus on part of the creative process, but are not sufficient alone to capture creative potential; these tests measure the aspect of creativity which allows production of a quantity of non-developed ideas, rather than a completed "work". For example, in the divergent-exploratory drawing task, the child or adolescent has to make many quick drawings using an abstract geometric form that is provided. Then in a second session, the same kind of task is proposed again but the stimulus is a photo of a common object. Each proposal must be original and different from previous proposals. For these divergent thinking tasks, we focus on the fluency score, such as the number of drawings or the number of story ideas proposed by the child. Second, convergent-integrative thinking tests are proposed to the child or adolescent, and a single production is requested. The "product" (e.g. drawing, story, etc.) generated by the child is assessed on a Likert scale from 1 (not at all creative) to 7 (quite creative). The scoring system, on which judges are trained, focuses on taking into account several elements from the set proposed, and synthesizing them in an original way.

Two aspects of EPoC protocols are thereafter subject to interpretation. First, the efficiency or the level of performance on each dimension for each content domain (such as divergent-exploratory thinking, and convergent-integrative thinking in the graphic domain) is reported. This is an inter-individual norm-referenced score. An individual is described relative to the performance of other individuals in the same age group. Second, an intra-individual profile of creative potential or the configuration of creative abilities is reported. Standard scores are used to determine the creative potential profile of the child. This allows an appreciation of the child's relative strengths and weaknesses. For example, for some children or adolescents, there is a relative strength in a certain domain of creative thinking (divergent-exploratory and convergent-integrative in graphic production compared to lower potential in the verbal-linguistic domain). For other children, the opposite pattern may be observed. Also, some individuals show relative strengths in divergent-exploratory thinking but weaknesses in convergent-integrative thinking in a given domain (or the opposite pattern). This intra-individual profile is therefore of interest, and complementary to a person's score in a between-person comparison.

18.5 Who Is the Best Judge of Creative Work?

For both measures of creative potential and creative achievement, there is the need to evaluate the originality and value of produced ideas. There is much debate, however, regarding "who" is best qualified to assess these (see, for example, Caroff & Besançon, 2008, Barbot, Tan, Randi, Santa-Donato, & Grigorenko, 2012; Kaufman & Baer, 2012; Long & Pang, 2015; Lu & Luh, 2012). Must one have a thorough knowledge of a subject, such as literature, in order to recognize a creative literary idea? Must one be creative oneself in order to accurately assess the creativity of others? Must one have extensive experience with children and adolescents in order to assess their creativity?

It is conceivable that the evaluation is carried out by the individual him- or herself (the creator), by peers, by an external person who knows the child or adolescent well (such as a parent), by a teacher, by a domain expert (artist, musician, or other experts depending on the assessment field), or by a psychologist (or other child-oriented professionals). Each of these possible evaluators will make judgements from his or her perspective. For example, an individual who evaluates his or her own work knows well the previous productions and can perhaps best appreciate the novelty of the current work. Peers can compare a new production to those produced by other people because they are very familiar with the common types of productions for their age and their environment. The assessment by a family including the parents of a child allows a contextualized evaluation and the life course of the individual can be taken into account. A teacher and/or expert brings to assessment his or her rating expertise and knowledge of typical products in a task or situation. In the case of a specialist teacher in one discipline (e.g. an art teacher) or a professional expert in a given field (professional artist, art critic …) thorough knowledge of a discipline with its criteria and its context will also be taken into account in the assessment. A psychologist or other professionals provide assessment methodology that reduces bias of measurement errors, such as the effects of "halo" according to which an evaluation could be influenced by *apriori* information like a student's grades in some school subject matters (e.g., a good student at school may be rated more highly than deserved).

These questions are important to be debated for creativity measurement, but they arise in general in other cases of assessment. Consider another example of evaluation: must one be particularly gifted in reading to assess the ability to read? Must be an accomplished writer to assess the verbal expressive ability of children? Regarding creativity, there is however a particularity that should be highlighted. Original ideas are, by nature, rare and the ability to detect them involves having a sufficient comparison base, or experience in a field, to appreciate the novelty when it does occur.

Exposure to products from a large number of individuals in a given situation facilitates the assessment of creativity because rare ideas can be more easily detected when the reference base of existing productions is well developed. A beginning teacher will have fewer points of comparison than an experienced teacher. A teacher specializing in art will have a greater knowledge base than a non-specialist teacher. A parent who has the experience of mainly his or her child may have difficulty evaluating the products of the child in an absolute way because that parent has few comparison points. In this sense, it is not uncommon for parents to find their children very creative, although the ideas are often similar to those of other children the same age. For example, one child drew a character "like Picasso" and his parents found it very creative, without knowing that all children in the class had seen a Picasso exhibit and they had all started working in this style following the field trip. In addition to different comparison bases for different assessors (parents, teachers, child, peers), it is conceivable that their definitions of creativity are slightly different and the weights of the criteria used vary also (Barbot et al., 2012). Thus the same production of a child evaluated by himself, his parents, his primary teacher and an expert in the field do not necessarily receive the same evaluation. Taking into account these elements, we consider that the ratings of teachers or experts who have specialized knowledge in a domain provide the most suitable appraisal of the creativity of a production. However, given the scarcity or difficulty of systematic access to expert evaluators, it is also reasonable to have an evaluation by a general teacher, a psychologist or another education specialist. The reliability of all these evaluations are greatly enhanced when the same rating scale standards and a corpus of previously generated productions are available as well as a standardized task compared all children, which allows a detailed comparison of their different productions.

18.6 Discussion and Conclusion

A fable about six "zoologists" from the Indian subcontinent captures well the state of the literature on creativity measurement. John Godfrey Saxe, an American poet and satirist, is known for his 1872 poem « The blind men and the elephant » based on the famous scientific expedition. The story goes like this:

> It was six men of Indostan to learning much inclined,
> Who went to see the Elephant (Though all of them were blind),
> That each by observation might satisfy his mind.
>
> The First approached the Elephant, and happening to fall
> Against his broad and sturdy side, at once began to bawl:
> "God bless me!—but the Elephant Is very like a wall!"
>
> The Second, feeling of the tusk, cried:"Ho!—what have we here
> So very round and smooth and sharp? To me't is mighty clear
> This wonder of an Elephant is very like a spear!"
>
> The Third approached the animal, and happening to take
> The squirming trunk within his hands, thus boldly up and spake:
>
> "I see," quoth he, "the Elephant is very like a snake!"
>
> The Fourth reached out his eager hand, and felt about the knee.
> "What most this wondrous beast is like is mighty plain," quoth he;
> "'Tis clear enough the Elephant is very like a tree!"
>
> The Fifth, who chanced to touch the ear, said: "E'en the blindest man
> Can tell what this resembles most; deny the fact who can,
> This marvel of an Elephant is very like a fan!"
>
> The Sixth no sooner had begun about the beast to grope,
> Than, seizing on the swinging tail that fell within his scope,
> "I see," quoth he, "the Elephant is very like a rope!"
>
> And so these men of Indostan disputed loud and long,
> Each in his own opinion exceeding stiff and strong,
> Though each was partly in the right, and all were in the wrong!
>
> So, oft in theologic wars the disputants, I ween,
> Rail on in utter ignorance of what each other mean,
> And prate about an Elephant not one of them has seen!

The parallel between the blind men interested in the elephant and educators interested in creativity is not hard to see (no pun intended !). Consider a few contradictions in the educational field that are compatible with the elephant tale.

- Many talk about creativity but few understand it, as evidenced by the interchangeable terms used in discussions of creativity (creative ability, talent, innovation,..).
- Many claim it is unmeasurable but many measures exist.
- Many consider it a highly complex phenomenon, but reduce it to divergent thinking.

It is our hope that the concepts presented in this chapter, the articulations provided, and the new measurement tool (EPoC) described, will shed light on these ongoing controversies. In particular, the approach to creativity measurement sketched in this chapter should help educators and researchers (a) to clarify the concepts they employ (e.g. creative potential), (b) to identify different levels of creativity with acceptable inter-rater reliability, and (c) to develop teaching programs to foster creativity in specific ways.

For example, using the EPoC measure of creative potential, it is possible to describe each child's profile in terms of relative strengths and weaknesses on two main process modes, divergent-exploratory and convergent-integrative thinking. These are measured within each major domain of creative activity (visual art, verbal-literary, science, math, social, music, kinesthetic). Thus, it is possible thanks to a clear measurement model to identify for a child the specific aspects of creative thinking on which to focus educational opportunities and exercises to promote creativity. This example offers both research and practical implications leading to potential studies of the frequency of each kind of profile of creative potential and the efficiency of training programs for each aspect of creative potential. In conclusion, resolving some controversies about the measurement of creativity may shed light on the how it can be defined and promoted as a function of the different goals that may be relevant in each specific educational setting.

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CODA: Creative Contradictions: Common Themes, Unique Insights, and Future Directions

Ronald A. Beghetto

Introduction

Volumes of this nature are not "one and done" reading experiences. Rather, there is richness and nuance that can be found after spending time sitting with and revisiting the chapters from the vantage point of one's own scholarly interests. The chapters in this book represent a wide array of perspectives on creative contradictions in education. In some cases, the authors propose new conceptual and theoretical insights to help guide current and future research efforts. In other cases, they present empirical explorations and concrete suggestions that have practical implications for teachers and students. In this way, the volume offers many different entry points for researchers interested in exploring creativity in educational contexts. Although the perspectives and insights are diverse, there is one theme that serves to unite all the contributions in this chapter. Specifically, the authors invite readers to rethink creative contradictions in education.

My aim, in this concluding chapter, is to briefly discuss this broader unifying theme and highlight the differing perspectives and insights presented by contributors to this volume. It is my hope that this discussion will serve as a jumping-off point for readers interested in challenging the typical ways of thinking about creative contradictions in educational settings.

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Rethinking Creativity in Educational Contexts

Educational settings provide a particularly promising, yet challenging context for exploring creative phenomena. Creativity, viewed from an educational perspective, represents a mercurial construct. It is difficult to pin down, constantly changing, and highly unpredictable. Several chapters examine the contradictory and often paradoxical relationship between formal education and creativity. Simonton (Chap. 1), for instance, provides a compelling and important reminder that more formal education is not always better and, in fact, may negatively influence personal (little-c) and consensual (Big-C) creativity. This is not to say that formal educational settings necessarily stifle creativity. Indeed, as Baer (Chap. 8) asserts, creativity is perhaps best thought of as a domain specific ability that thrives in particular domains and thereby can (and should) be developed in the context of traditional academic subject areas and academic content standards (see also Tanggaard & Hjort, Chap. 13). Moreover, several authors highlight how schools and classrooms can be ideal settings for identifying and supporting the creative potential of young people (e.g., Karwowski, Chap. 6; Lubart & Besançon, Chap. 18; Runco, Chap. 5 Smith & Smith, Chap. 2; Tinio & Barbot, Chap. 7; Zosh et al. Chap. 10).

Supporting creativity in the context of academic subject matter constraints is, of course, easier said than done. As several contributors highlight, schools and classrooms are shot through with sometimes hidden (and not so hidden) barriers, including: varying and contradictory conceptions of creativity (Haavold & Birkeland, Chap. 11; Hong et al. Chap. 17; Houmann, Chap. 16; Karwowski, Chap. 6; Middlebrooks, Chap. 15; Smith & Smith, Chap. 2; Tan, Chap. 14); inherited educational dogmas (Ambrose, Chap. 4), and pressures to cover content and meet external accountability mandates (Burnett & Haydon, Chap. 12; Hong et al. Chap. 17). Such barriers can, in turn, undermine students and teachers willingness to engage in creative thought and action (Glaveanu & Beghetto, Chap. 3; Simonton, Chap. 1; Zosh et al. Chap. 10).

How then might creativity be supported in environments that seem antithetical to the conditions necessary for creative thought and action? Fortunately, the contributors to this book do not leave readers with a gloomy message of creative doom in schools and classrooms. Rather, the authors of the chapters collected herein provide readers with new ways of thinking about creativity in educational settings. In what follows, I briefly highlight three core insights I gleaned from the chapters, which can serve as starting points for rethinking the seemingly paradoxical and at times contradictory relationship between creativity and formal schooling environments.

Core Insight 1: View Contradictions as Creative Opportunities

When faced with contradictions we may feel compelled to choose sides or attempt to resolve differences by ignoring them. Contributors to this book help us recognize that creative thoughts and actions often emerge out of contradictions. Indeed, the way that most researchers' define creativity itself is a blend of the seemingly contradictory elements of originality and meeting task constraints (Simonton, Chap. 1; Smith & Smith, Chap. 2). By helping teachers and students re-interpret contradictions as creative opportunities (Runco, Chap. 5) we may find new and meaningful ways to work with different perspectives and goals rather than try to immediately erase or worked against them (Glaveanu & Beghetto, Chap. 3).

Contributors to this volume provide several key insights for rethinking creative contradictions. Baer (Chap. 8), for instance, highlights how the seemingly opposing goals of meeting predefined curricular standards can work in conjunction with supporting students' domain-specific divergent thinking abilities. Similarly, Root-Bernstein and Root-Bernstein (Chap. 9) highlight how "copying" from diverse models of accomplished creators can support students' movement from "re-creating" to "creating" their own unique identities.

Tan (Chap. 14) discusses how blending the seemingly incompatible cognitive functions of memorization and imagination can support creativity in classrooms. Several other authors highlight how positioning education as serious business and play as frivolous can be counterproductive. Middlebrooks (Chap. 15), for instance, stresses the importance of enjoyment in learning and work. Zosh and her colleagues (Chap. 10) similarly outline how *playful learning* can serve as a new vision for the kinds of schools that might more effectively blend creativity and academic learning.

In sum, reconsidering contradictions can go a long way in helping researchers and educators re-imagine the nature of schooling, including recognizing how creativity-supportive changes in schools and classrooms can be attained through more incremental (Burnett & Haydon, Chap. 12) and smaller scale efforts (Tanggaard & Hjort, Chap. 13), rather than more radical or revolutionary approaches. As Ambrose (Chap. 4) asserts, when researchers and educators adopt a more generative worldview they can creatively restructure the broader project of education itself. A central message that comes through many of these chapters is: Creativity can be found in a balance between the tensions and contradictions – not at the extreme ends.

Core Insight 2: Recognize and Work with Differing Conceptions of Creativity

Beliefs about creativity matter and several contributors highlighted how differing conceptions of creativity can support and impede efforts aimed at encouraging student and teacher creativity. Several authors focused on conceptions of students and teachers by offering new theoretical models and insights. Karwowski (Chap. 6), for instance, introduced a topological framework that endeavors to provide a more nuanced representation of different types of students' creative expression that can manifest in educational settings. Middlebrooks (Chap. 15) drew from existing theory and literature to highlight how overly narrow conceptions of fun, learning, and creativity can undermine students' creative potential. Similarly, Tan (Chap. 14) provided an overview of various theoretical and philosophical conceptions of creative teachers and students.

Other authors focused on empirical explorations of teacher and student conceptions. Hong et al. (Chap. 17), for example, explored and discussed conceptions of children and teachers – highlighting various contradictions, discrepancies, and implications that can be draw from their exploration. Tanggaard and Hjort (Chap. 13) also demonstrated by way of an empirical study, how modest changes to instructional practices can be supportive of creativity and thereby challenge conceptions of creative teaching that assert a need for more radical instructional reform efforts.

In addition to exploring teacher and student conceptions, several contributors examined and discussed the conceptions of teacher educators. Haavold and Birkeland (Chap. 11), for instance, focused on teacher educators' conceptions of creativity and highlighted themes and perspectives in relation to current research on mathematics and creativity. Houmann (Chap. 16) also discussed conceptions of teacher educators, but focused on music teacher educators.

Still other authors, focused on even broader perspectives. Smith and Smith (Chap. 2), for example, revisited definitions of creativity commonly held by creativity researchers and offered a new take on the traditionally used criteria. Ambrose (Chap. 4) highlighted how narrowly conceived worldviews can constrain and dupe people into believing they are being creative when, in fact, they are only operating at a very surface level understanding of educational improvement.

Taken together, contributors to this volume provide readers with various insights into differing conceptions of creativity across multiple populations, domains, and units of analysis. Supporting creativity in educational settings will require uncovering and working with sometimes contradictory conceptions of creativity. At times this may require resisting the temptation to simply dismiss divergent conceptions by labeling them as "misconceptions" and do the more difficult work of trying to understand and learn how and why various populations of people in and across diverse settings conceptualize creativity in different ways. If we develop an understanding of how varying conceptualizations of creativity operate amongst different people in diverse educational settings, then we will be in a better position to know how to work within and across those differences. Fortunately, the contributors to this volume provide ample insights that can go a long way in supporting such work.

Core Insight 3: Focus on Nurturing Creative Potential in Educational Settings

Developing students' creative potential is, as several contributors to this volume assert, one of the most promising features of any educational environment. Indeed, formal educational environments introduce young people to various academic and performance domains (e.g., science, mathematics, sports, the arts). This formal introduction coincides with and can support the development of young people's creative interests, aspirations, and identities (Karwowski, Chap. 6; Tinio & Barbot, Chap. 7). As such, schools and classrooms can play a non-trivial role in helping young people become aware of and start developing their competence in various domains.

Just because educational environments can serve as key sites for supporting creativity does not, of course, mean that teachers' and students' potential will be supported and developed in such sites. As contributors to this volume highlight, there are multiple factors that can serve as impediments to supporting creative potential. Simonton (Chap. 1), for instance, notes that formal schooling environments often require that students narrow their focus, which can result in giving up on a creative hobby or interest. Along similar lines, several authors note that pressures to conform to pre-determined learning outcomes can result in missed opportunities to identify and support students' developing creative potential (Ambrose, Chap. 4; Burnett & Haydon, Chap. 12; Simonton, Chap. 1; Zosh et al. Chap. 10).

Although it is true that teachers and students may feel pressures to conform to narrowly defined learning goals and achievement outcomes, creative potential can still be cultivated in such environments. In order for this to happen, however, opportunities to develop potential will need to be more purposefully and systematically designed into learning environments (Tinio & Barbot, Chap. 7). This includes, establishing meaningful encounters with difference (Glaveanu & Beghetto, Chap. 3), providing students with opportunities to learn and think creatively within the constraints of academic domains (Baer, Chap. 9), providing opportunities for students to learn with and from diverse creative models (Root-Bernstein & Root-Bernstein, Chap. 9), and recognizing that there may be different types of creative expression that can manifest in and be more or less compatible with the aims of particular educational environments (Karwowski, Chap. 6).

In addition to finding opportunities to support creativity in schools and classrooms, Smith and Smith (Chap. 2) assert that rethinking the definition of creativity itself may help in shifting focus from production to potential. Specifically, creativity researchers tend to require usefulness as a core criterion for creativity. Smith and Smith, however suggest that a more fruitful definition of creativity – particularly in educatoinal contexts – would be one that requires a blend between novelty and the *potential* to be useful. This relaxes the constraint requiring *demonstrated* usefulness, but still protects against silly or meaningless ideas. In this way, novel ideas that have not yet (or may never) come to fruition can still be viewed as creative. Not only would this help in recognizing the creative potential of young people who have not had the time or training to realize that potential, it would also provide a more encompassing classification of creative efforts by more accomplished creators which were never fully realized (e.g., Leonardo's 'helicopter').

In addition to rethinking the definition of creativity, using measures of creativity that focus on creative potential are also needed. Lubart and Besançon (Chap. 18) discuss how creativity researchers tend to rely on measures of creativity that focus too much on divergent thinking or creative accomplishment and thereby fail to represent the more nuanced features of creativity, including creative potential (see also Tinio & Barbot, Chap. 7). In sum, several contributors highlight how important it is for creativity researchers and educators to rethink the emphasis placed on creative performance and instead focus their efforts on how to better conceptualize, measure, and support students' creative potential in educational settings.

Concluding Thoughts and Future Directions

My goal in this coda was to highlight common themes and unique insights within and across the chapters of this volume. I focused my attention on the unifying theme of rethinking creative contradictions in education. I also noted how this theme might be further sub-divided unto three core insights: *View contradictions as creative opportunities; Recognize and work with differing conceptions of creativity;* and *Focus on nurturing creative potential in educational settings.*

Researchers and educators can draw on these core insights to help direct and further focus their efforts to support creativity in schools and classrooms. In some cases, these efforts may be focused on more micro-level endeavors, such as working with particular groups of students and teachers to find ways to support creative thought and action in specific educational situations and contexts. In other cases, more ambitious macro-level efforts may be necessary to address inherited dogmas, practices, and externally mandated constraints that undermine students' and teachers' ability or willingness to be creative. In all cases, however, creativity and collaboration on the part of researchers and educators will be needed to help work within and, when necessary, work against creative contradictions in schools and classrooms.