Building Creative Thinking in the Classroom: From Research to Practice

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Abstract

Classroom instruction often overlooks the critical importance of encouraging and even explicitly teaching students to think creatively. Yet classroom learning offers an ideal opportunity for students to not only master a body of content knowledge but also to work to creatively apply that knowledge, a skill that is important for success in any environment. In this paper, we review literatures on creativity, focusing on findings that we believe clearly inform how it can be taught. We argue that some of the changes in the ability to think creatively arise due to factors that are directly manipulable in the classroom (e.g., opportunities for open-ended questioning) whereas other changes stem from increases in capacities of basic cognitive function. Finally, we propose simple guidelines, based on theories and research on creativity, for how teachers can build students' ability to think creatively and to apply content knowledge in creative and novel ways.

KEYWORDS: creativity, classroom instruction, problem solving

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Despite the importance of both content knowledge and creative thinking for educational and professional achievement, classroom instruction often provides few opportunities for students to think creatively. Nevertheless, creative thinking and problem solving can be built into instruction in many ways. For example, teachers can encourage students to seek out new connections between disparate ideas or ask students to offer multiple and varied solutions to complex problems. If the ability to be creative is indeed vital for students' future success, teachers must explicitly foster and teach creativity in school (e.g., Robinson, 2001). On this view, creativity training should be a key component of primary and secondary education.

Nevertheless, creativity training only makes sense if we assume that everyone can think creatively and that creativity can be influenced. Fortunately, many researchers have argued—and in some cases demonstrated empirically—that every individual possesses the ability to think creatively, at least within particular contexts (e.g., Amabile, 1996; Kaufman & Beghetto, 2009). Further, research has shown that creative thinking is influenced by various circumstances, including whether work is collaborative and the extent to which individuals are motivated to solve a problem (e.g., Brophy, 2006). These findings support the idea that creativity is pliable and that creative thinking can and should be taught in some way (e.g., DeHaan, 2009).

Here we review research findings that we believe support specific techniques for integrating into instruction activities and practices to help students become more creative thinkers. Taken together, the findings suggest that a student's ability to creatively apply information they have learned—creativity derived from content knowledge—is best supported when creative thinking is taught in tandem with subject matter content, rather than in a standalone way, divorced from content. We argue that despite the lack of a thorough understanding of creativity as a construct, educators should take full advantage of what scientists have learned and continue to learn about creativity by incorporating into classroom instruction pedagogical techniques and activities that will provide our future society with the creative thinkers it will no doubt desperately need. Ultimately, we offer guidelines, consistent with research on creativity, to facilitate teachers in enhancing instruction to build each student's capacity to think creatively. While previous attempts have been made to develop creativity training and implement it in schools (see Scott, Leritz, & Mumford, 2004 for a review), many of them involve training that is either only relevant within a given performance domain (e.g., playing the violin), or based on an abstract notion of creativity that makes little reference to content knowledge (but see Schacter, Thum & Zifkin, 2006). As a result, in order to implement a creativity program, a teacher may potentially need not only to learn the new program, but also to set aside standard curriculum in order to conduct the program. Moreover, few teachers feel that they are sufficiently trained to support students' creative potential (Kampylis, Berki, & Saariluoma, 2009). What we advocate and offer here are simple, yet effective activities and pedagogical techniques that can be embedded into current instruction in any subject matter area. This allows the teaching of creative thinking to be combined with the teaching of subject matter content, without losing instructional time.

We first assess how creativity has been contemplated through theory, with a close eye toward questions that are most relevant to education. We then review research on factors that affect one's ability to creatively solve problems over the long-term, as well as research on factors that enhance creative thinking in a more short-lived fashion (e.g., in a lab test or a classroom activity). We also discuss the role of certain cognitive functions in creative problem solving, including how those cognitive functions and thus resulting creativity can be trained. Finally, we offer some simple guidelines, based on theories and research on creativity, for how teachers can foster students' creative thinking in any area of instruction.

Creativity in Theory

Creativity researchers have contemplated the construct of creativity from many approaches, addressing issues such as how creativity is defined, how it can be measured, and whether it is a fixed trait (see Kozbelt, Beghetto, & Runco, 2010 for a review). Creativity has been defined in terms of many phenomena: the context of one's personality, the products one can produce, the environment one is in when generating a creative product, and one's mode of thinking when creating an original product or response (e.g., Rhodes, 1961). The question of how to measure creativity is closely tied to how creativity is defined, as the appropriateness of any measure depends on which hypothesized aspects of creativity are being assessed. Even upon examining just one of the many published tests of creativity—for example, the Torrance Test of Creative Thinking (Torrance, 1974)—one will find that creativity is assessed by measuring not one, but several components of creative thinking (e.g., fluency, originality, elaboration). This is consistent with the idea that there are different aspects of creativity.

In the context of education, perhaps the most valuable question to ask is whether or not creativity is fixed. Namely, creativity could be a construct that is static (i.e., a relatively stable trait), or it could be modifiable through development, formal schooling, or general life experience. Consistent with this distinction, creativity has been conceptualized in terms of the magnitude or level of creative thinking one engages in, with only some levels able to be increased in response to external factors (e.g., Csikszentmihalyi, 1996). Creativity can take the form of a more objective "Larger-C" or "Big-C" or a more subjective "smaller-c" or "little-c". Well-known inventions or famous works of arts would likely be associated with the former (e.g., Mozart's concertos, Picasso's paintings, DaVinci's inventions); this Big-C would not necessarily be found in everyone and would change little with experience or development (e.g., Simonton, 1994). The latter, little-c, in contrast, would denote everyday creativity that is likely found in everyone to some degree and may be dependent upon area-specific content knowledge (e.g., Richards, 2007).

The distinction between Big-C and little-c speaks to whether creativity derives in part from content knowledge. Recall that creativity could be a very general quality, or creativity could derive from the possession of content knowledge within a given domain (see Sternberg, 2005 for a more in depth discussion). A middle ground would suggest that creativity has multiple components, some derived from content knowledge and others more general (e.g., Plucker & Beghetto, 2004). Given our interest in joining classroom instruction of content with the promotion of creative thinking, our focus is on creativity that derives from content knowledge: we assume that at least some components of creativity derive from content knowledge and that these components can be enhanced or taught in everyone (see also Haring-Smith, 2006).

Research Related to Creativity

Research from various disciplines has explored instruction, experiences, and cognitive processes that play a role in building students' abilities to think creatively. Our review of the literature begins with an examination of how individuals learn to flexibly apply the knowledge they have acquired—in a long-lasting way—in order to think and problem-solve creatively.

Cultivating the Ability to Apply Knowledge Creatively: Developing Adaptive Expertise

Content knowledge within a domain has been argued to be the foundation for creative thinking and innovation (e.g., Weisberg, 2006). According to this view, creative thinking cannot occur unless one has first mastered a body of content knowledge (e.g., Csikszentmihalyi, 1996).

However, content knowledge by itself is unlikely to be sufficient to support creative thinking; creativity also requires the ability to apply knowledge in flexible ways that go beyond the context in which the knowledge was acquired. This additional ability can be specified by considering two alternative kinds of expertise: “routine expertise” and “adaptive expertise” (Hatano & Inagaki, 1986). Routine expertise requires knowledge of specific information that allows one to efficiently perform a task according to a well-defined procedure. Adaptive expertise, in contrast, requires this foundation *and* an understanding of why procedures work, how to modify them, and how to invent new ones (e.g., Hatano, 1982). Adaptive experts’ deep understanding of procedures allows them to find patterns in information that supports adaptation and application of knowledge in novel situations (e.g., Ericsson, 1998; Schwartz, Bransford, & Sears, 2005). Moreover, Crawford and Brophy (2006) suggest it is adaptive expertise that engages the problem-solving processes that allow people, and in particular experts, to keep adapting to novel circumstances. Evidence of this comes from Weisberg (2006), who examined case studies of artists, scientists, and inventors and concluded that expertise—built from content knowledge—influences one’s ability to solve problems creatively. Thus, creativity is driven by deep understandings and representations within a domain that allow one to use knowledge and information in new ways.

If adaptive expertise underlies a child’s ability to think creatively, educators must determine how to best teach or support its development. At a basic level, teachers must ensure that students have sufficient content knowledge. Moreover, educators must give students opportunities to flexibly apply content knowledge; it appears that this can be accomplished by offering students active learning experiences in order to facilitate the construction of mental models. To study what conditions permit individuals to build a body of knowledge and apply it in various situations, Hatano & Inagaki (1992) considered children learning how to raise animals. After comparing studies in which children learned about animals either with or without also raising those animals at home, the authors concluded that raising animals at home led children to have a better understanding of a situation, allowing children to construct mental models of the animals. The authors argued that mental models are what supported the children's ability to flexibly apply their knowledge of the animals, ultimately leading to adaptive expertise. Oura and Hatano (2001) further explored the role of mental models, and in particular mental models of other people, in the acquisition of knowledge and expertise. Their study compared how novice and junior expert pianists played during a performance. Overall, the findings demonstrated that the goals for the two groups were different. While novices aimed to have an accurate and smooth performance, junior experts aimed to refine their performance based on their mental models of the audience. The junior experts made adjustments in response to their perceptions of the audience's reactions and beliefs about whether the performance conveyed an understanding of the structure of the piece. More generally, the study supports the idea that knowledge gained through experience aids the construction of mental models—in this case mental models of others' beliefs—and that these models allow us to use our knowledge in appropriate ways depending on the situation. Besides creating mental models, Hatano and Oura (2003) argue that individuals can build flexible knowledge through practice that has varied and changing demands. Being able to successfully adjust to unexpected and frequent changes requires flexible application of prior knowledge. In theory, this will help one develop adaptive skills. These conclusions point toward activities and practices that teachers could build into classroom instruction in order to increase students' abilities to use information flexibly. In particular, teachers should include learning that is hands-on and experience-based to motivate students, supply sufficient information and experiences so mental models can be formed and used flexibly, and provide variable practice. These pedagogical techniques could help students apply their knowledge flexibly, building adaptive expertise and thus the capacity to be creative.

Manipulating/Enhancing Creative Thinking and Creative Problem Solving

The previous section focused on the relationship between creativity built from content knowledge (adaptive expertise), and how this capacity can be supported over the long term. Creativity has also been shown to be modifiable in ways that are equally evident but more transient. That is, one's ability to think creatively and to produce a creative output can be amplified in response to particular circumstances, resulting in short-lived yet significant effects. Here we consider effects on creativity of factors that can potentially be manipulated in a classroom setting: a) collaboration, b) exposure to ideas of others, and c) evaluation of ideas.

Collaboration. Numerous studies have considered the effect of collaboration on creative problem solving (e.g., Diehl & Stroebe, 1987). Although people tend to believe they produce more ideas working in a group than alone (Paulus, Dzindolet, Poletes, & Camacho, 1993), brainstorming in groups appears to be less productive than brainstorming on one's own, as measured by the number of solutions per person and the uniqueness of solutions (see Mullen, Johnson, & Salas, 1991 for a review). However, a recent study suggests that differences in productivity between groups and individuals may depend on the task at hand (Brophy, 2006). Participants were presented with single or multi-part creative problem-solving tasks that involved real-world problems facing a university. Performance of "nominal groups" (i.e., individuals working independently) was compared to that of "interactive groups" (i.e., individuals engaged in collaboration). The results revealed that the type of group that was more successful varied with the type of problem: while the nominal groups outperformed the interactive groups on single-part tasks (based on the number and originality of solutions), the reverse was true for the multi-part tasks. These findings suggest the need to identify the type of problem at hand before turning to group work, as collaboration is most beneficial for solving complex problems having multiple parts and individual study is best for solving single-part problems.

In addition to exploring how creative problem solving differs for groups versus individuals, research has investigated particular factors that influence group learning or group brainstorming abilities (e.g., Meadow, Parnes, & Reese, 1959). For example, Sawyer and Berson (2004) examined the role of external representations—in this case lecture notes—in group study discussions. Their results showed that when lecture notes were presented, group conversation was more formal with many clarification questions and more elaborate explanations, suggesting that external representations can serve as scaffolds for collaborative learning. These findings have clear implications for education: when teachers choose to have students collaborate, they should supply external representations such as directed questions, lecture notes, or graphic organizers to support creative problem solving and learning.

Exposure to ideas. Exposure to other people's ideas or information has been shown to influence creative problem solving (e.g., Friedrich & Mumford, 2009). For instance, Dugosh and Paulus (2005) explored the effects of idea exposure in brainstorming. Participants were presented with a large or small number of common or unique ideas and asked to provide solutions to a problem; unsurprisingly, those who saw more ideas generated a greater number of additional ideas. In the same study, the authors looked at how comparing oneself to others affected idea generation. Participants in a "high social comparison" condition were told that the ideas they saw came from a creative person, while participants in a "low social comparison" condition were told that the ideas they saw were chosen randomly by a computer program. The results revealed that more ideas were generated under the high social comparison condition. Effects on idea generation of the number of ideas one is exposed to as well as the origin of the ideas suggest that both cognitive and social factors influence brainstorming, an important activity for creative problem solving.

Moving beyond behavioral research, researchers have used functional Magnetic Resonance Imaging (fMRI) to investigate whether factors such as idea sharing produce observable differences in brain activity (e.g., Limb & Braun, 2008). In a study by Fink and colleagues (2010), participants were asked to generate either alternative uses of objects or characteristics of objects while either reflecting on their own ideas or considering the ideas of others. When confronted with others' ideas ("cognitive stimulation"), the ideas participants generated were judged by independent raters to be more original. Moreover, differences were observed in activation in particular brain regions (bilateral cingulate cortex and occipital cortex) depending on whether participants were confronted with others' ideas before having to generate uses. These results demonstrate that differences associated with creative problem-solving behavior can be observed in the brain, providing converging evidence that exposure to others' ideas has a positive impact on creativity.

Evaluation of ideas. In addition to collaboration and idea exposure, research has considered the effect on idea generation of having to evaluate solutions. Several studies suggest that the generation of ideas, in particular creative ideas, can be enhanced when individuals are asked to evaluate others' ideas or consider the implications of their own ideas (e.g., Byrne, Shipman, & Mumford, 2010). For instance, Lonergan, Scott, and Mumford (2004) explored how revising and appraising ideas influences creative problem solving. Study participants were given ideas that were considered non-original, original, or highly original about advertising campaigns and had to appraise and revise the ideas. They were told to focus on criteria for assessing ideas that emphasized either generation (i.e., originality, adaptability, viability over the long-term, benefits) or operating efficiency (i.e., quality, how difficult it would be to gain acceptance, gains in the short-term, and risk minimization). Better plans were produced: a) when criteria emphasizing generation were applied to less original ideas, and b) when criteria emphasizing operating efficiency were applied to more original ideas. These results suggest that prompting individuals to evaluate ideas might produce more original ideas and improve problem-solving performance. However, the results also imply that it is important to apply standards that vary with the context that the plan will be implemented in. In other words, in addition to encouraging many ideas, one also has to consider how efficiently a given idea will work in a particular context.

Executive Function and Creative Thinking

In addition to thinking about how creativity can be altered in a long-term way (by building adaptive expertise) as well as a short-term way (by manipulating certain factors and conditions), it is important to understand the role played by various cognitive functions during creative thinking and creativity training. In particular, Diamond (2006) has argued that executive function processes—and intentional efforts to train these processes—are critical for creativity. Executive function processes are basic cognitive functions that include maintaining information in working memory, inhibiting inappropriate actions, and shifting one's perspective or focus of attention. These functions allow people to recall information from memory, plan future events, and ultimately to apply knowledge and draw novel associations to solve problems. Accordingly, Diamond (2006) maintains that executive functions underlie aspects of creative problem solving including our abilities to generate novel responses, to consider alternatives, to draw connections between seemingly unconnected items, and to disassemble elements from the whole and recombine them in new ways.

A number of studies have highlighted the importance of executive functions for creativity. Storm and Angello (2010) investigated inhibitory processes, ultimately suggesting that these facilitate one's ability to solve problems (e.g., by helping one ignore irrelevant information). Moreover, individuals who are very creative tend to have unusually high and flexible levels of cognitive control (Zabelina & Robinson, 2010). Research has also shown that executive function can be trained in classroom settings (Diamond, Barnett, Thomas, & Munro, 2007); assuming that executive functions are implicated in creativity, this research suggests way in which creativity can be trained, as boosting executive function would in turn enhance creativity. Particular strategies used in the study included using external mediators to help remind students to use time wisely and having students engage in dramatic play to pretend to be someone else.

Guidelines for Encouraging Creativity in the Classroom

Scott, Leritz, and Mumford (2004) suggest that if teachers employ a simple set of strategies, they can positively influence a student's divergent thinking. Accordingly, we present eight guidelines based on the findings described above that can be applied in any classroom. By using these guidelines, teachers can support creative problem solving through instruction in any content area.

1. **Supply students with a wealth of information in specific content areas, and take steps to ensure that students retain that information**. Consistent with the idea of adaptive expertise, providing students with sufficient domain-specific knowledge allows

students to gain expertise or fluency and thereby apply knowledge flexibly. At an even more basic level, without content knowledge, students won't have anything to think flexibly about. A number of actions can be taken to help students master in-depth information in specific content areas. For instance, students need to be provided with the "big picture" of what they are learning in a way that illustrates how particular pieces of content relate to one another. In addition, material should be presented multiple times through multiple modalities, and students' learning needs should be evaluated regularly throughout the learning process (Hardiman, in press). As for helping students retain what they have learned, arts integration—the use of arts activities to deliver content—may help students form stronger, longer lasting memories (Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011). Another useful strategy for enhancing retention is to prompt students periodically to retrieve from memory the information they have already learned (Karpicke & Roediger, 2008).

2. **Encourage idea generation by posing questions or problems that have more than one correct response**. By asking questions that have multiple responses, teachers give students opportunities to think of alternative ways to solve problems. Also, because convergent-thinking approaches (e.g., asking questions that have only one correct answer) tend to dominate educational practice—possibly because they are the basis for many accountability measures (Runco, 2004)—teachers have to make a concerted effort to interact with students through more multi-response queries. For example, content is taught by eliciting responses from the class, typically via very direct questions with very specific answers (e.g., "Is littering a form of pollution?"; "In what year did the US join World War II?"). This same information could be elicited by posing a more open-ended

question so that the answer is still found (and relatively quickly), but students also have to think more broadly about the topic (e.g., “What is an example of a pollutant?”; “How did the US become involved in World War II?”).

3. **Ask students to offer multiple ideas to any open-ended prompt and remind students to make each solution as varied as possible.** Individuals who are presented with more ideas produce more additional ideas (e.g., Dugosh & Paulus, 2005); a straightforward way to introduce students to more ideas is to pose questions that have multiple responses. Students’ sharing their ideas with the class may trigger new ideas for other students. Presentation of open-ended prompts is easily incorporated into classroom instruction. For instance, in introducing a topic, the teacher could ask students to state what they would like to learn. In this way, each student has the opportunity to generate multiple responses which have to be different from one another and from those generated by peers. Open-ended prompts are also appropriate when students brainstorm potential ways to approach some task. For example, instead of asking, “What is the best solution?” a teacher could ask the class to “Name as many different solutions as you can think of,” which encourages a diverse array of unique responses.
4. **For each potential solution that a student suggests, ask the student to also think about implications and implementation**. The ability to generate creative ideas can be enhanced by having students forecast the effectiveness and implications of their proposed solutions (Byrne et al., 2010). For example, if, in response to a prompt, students offered ways in which pollution could be reduced, for each solution generated, teachers could ask students to think about how the proposed actions would affect their home and school environments, as well as how feasible the solutions would be to implement. Forecasting

might also be useful for helping students understand and use problem-solving techniques that are new to them. Imagine, for instance, that a teacher asked his or her students how they would go about solving an algebraic inequality. The teacher might encourage students to specify and forecast at least the first few steps of a solution; in doing so, students might recognize whether they are on the right track.

5. **Include group work opportunities when appropriate, and make the most of them**. During collaboration, teachers can stimulate improvisation between student and teacher by "revoicing," the practice of offering something new in return whenever students give an answer (e.g., "Yes, and…") (Sawyer, 2006). This sort of exchange may bring to mind unexpected ideas and encourage students to come up with even more creative responses or solutions. Also, group work is particularly effective when students are presented with multifaceted problems (Brophy, 2006), as finding solutions to complex problems might require more varied experience and knowledge. Teachers should work to incorporate group work that involves multipart problems (e.g., creating an imaginary civilization; enhancing a piece of current technology).

6. **Give students a novel relationship and have them generate items that, when related, exemplify that relationship**. A key aspect of creativity is having adaptive expertise, or sufficient content knowledge and the ability to use that knowledge flexibly. Tasks aimed at developing adaptive expertise should require students to extract from their own knowledge specific pieces of information that fit novel criteria. In essence, activities like these constitute shorter-term, relatively constrained creative problem-solving tasks. A clear example of this sort of task is the common analogy. Solving analogies requires identifying the relationship between two words and then choosing which of several pairs

of words share the same relationship. The task can be made generative (and perhaps less intimidating) by having students come up with pairs of concepts that share the target relationship rather than having students select pairs from a set.

7. **Provide students with two or more unrelated ideas and ask them to find a novel relationship.** Given the argument that executive functions are important for creativity (Diamond, 2006) and the finding that creative individuals exhibit more flexible cognitive control (Zabelina & Robinson, 2010), teachers should help students develop cognitive flexibility by offering them opportunities to enhance their representations of concepts and information. Identification of a novel relationship between seemingly unrelated items requires attention to nuanced, less obvious, or previously unrecognized characteristics of objects or ideas. For example, consider a task in which students are told they must choose three objects from a larger set, and they must decide which objects would serve the most purposes. Teachers could present students with a set of objects (e.g., a pencil, chalk, a branch, charcoal) and a set of functions (e.g., something to write with; something that can be used to create heat) and ask students which objects could be used for each function. While students will likely come up with conventional uses first (e.g., a pencil as something to write with), the task might encourage them to see other uses for those objects as well, thus establishing new, creative relationships between objects and functions. This kind of task could be expanded to content instruction by having students find relationships between seemingly disparate ideas. An example might be having students try to relate the worldwide popularization of hip-hop or other American music to the protests of youth in the Middle East against dictatorships.

8. **Include external mediators in certain group work situations.** External mediators can take the form of basic literal guides such as notes or worksheets (Sawyer & Berson, 2004) or more unconventional, idealized forms such as a piece of art. Either way, such tools can act as a springboard for discussion. Teachers can incorporate external mediators into instruction by, for example, providing students with a checklist that suggests steps or actions students might take based on the resources they have at their disposal. Research has shown that groups produce more ideas and more original ideas when provided with a checklist that relates to the goals of the task (Warren & Davis, 1969).

Conclusion

The skills necessary for progress in our society, regardless of context, are continually changing with the priorities of our economy and our culture more generally. Currently, our economy is transitioning from one based on manufactured goods to one based on information and new ideas. As a result, future progress and achievement will require citizens to have a strong foundation of knowledge as well as the ability to think creatively (e.g., Drucker, 1993; Sawyer, 2006). These capacities are critical for success not only in the professional world but also in education: content knowledge and creative use of that knowledge are what make it possible for students to apply what they have learned to solve new problems in situations that differ from those in which information was initially learned (Hardiman, 2010; Rotherham & Willingham, 2009). The capacity to use knowledge to find better solutions to problems will allow students to excel in classroom, on educational assessments, and well beyond as they advance in their careers and become life-long learners.

We have reviewed a small piece of what we know about creativity and how it can be influenced, both in the long term and the short term. This research has clear implications for teaching creativity, and we have attempted to extract key fundamental ideas and forge them into simple guidelines any teacher can use. We intend for the guidelines to be an accessible and useful tool for teachers as they work to convey content knowledge through activities that promote creativity so that students will be prepared for the needs of an ever-evolving society.

As future work continues to address questions about creativity through theory, empirical research, and practical application in educational settings and beyond, we must remember that creativity can be considered from a multitude of perspectives because it has a multitude of facets. As has been elegantly stated by Kozbelt, Beghetto and Runco (2010), "…the phenomenon of creativity, richly considered, involves many nuances and interpretations; only rather narrow aspects of creativity are readily understandable in terms of empirically falsifiable hypotheses, with resulting verdicts that suggest definite winners or losers" (p. 23).

For every study of creativity that has been completed, there are ten studies yet to be undertaken. So although we should not jump to the conclusion that any finding regarding creativity is "fact," we cannot afford to postpone the encouragement and teaching of creativity in our classrooms until we have a solid understanding of creativity as a construct, a state of affairs that is likely many years away.

References

Amabile, T. M. (1996). *Creativity in context*. Boulder, CO: Westview Press.

Brophy, D. R. (2006). A comparison of individual and group efforts to creatively solve contrasting types of problems. *Creativity Research Journal, 18*(3), 293-315.

Byrne, C. L., Shipman, A. S., & Mumford, M. D. (2010). The effects of forecasting on creative problem-solving: An experimental study. *Creativity Research Journal, 22*(2), 119-138.

Crawford, V. M., & Brophy, S. (2006). *Adaptive expertise: Theory, methods, findings, and emerging issues.* Retrieved April 7, 2011, from http://ctl.sri.com/publications/downloads/AESymposiumReportOct06.pdf

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention.* New York: Harper-Collins.

DeHaan, R. L. (2009). Teaching creativity and inventive problem solving in science. *CBELife Sciences Education, 8*(3), 172-181.

Diamond, A. (2006). The early development of executive functions. In F. I. M. Craik (Ed.), *Lifespan cognition: Mechanisms of change.* (pp. 70-95). New York, NY US: Oxford University Press.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*(5855), 1387-1388.

Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology, 53*(3), 497-509.

Drucker, P. F. (1993). *Post-capitalist society*. New York: HarperBusiness.

Dugosh, K. L., & Paulus, P. B. (2005). Cognitive and social comparison processes in brainstorming. *Journal of Experimental Social Psychology, 41*(3), 313-320.

Ericsson, K. (1998). The scientific study of expert levels of performance: General implications for optimal learning and creativity [1]. *High Ability Studies, 9*(1), 75-100.

Fink, A., Grabner, R. H., Gebauer, D., Reishofer, G., Koschutnig, K., & Ebner, F. (2010). Enhancing creativity by means of cognitive stimulation: Evidence from an fMRI study. *NeuroImage, 52*(4), 1687-1695.

Friedrich, T. L., & Mumford, M. D. (2009). The effects of conflicting information on creative thought: A source of performance improvements or decrements? *Creativity Research Journal, 21*(2-3), 265-281.

Hardiman, M. M. (2010). The creative-artistic brain. In D. Sousa (Ed.), *Mind, brain, and education: Neuroscience implications for the classroom* (pp. 226-246). Bloomington, IN: Solution Tree Press.

Hardiman, M. M. (in press). *The brain-targeted teaching model for 21st century schools*. Thousand Oaks, CA: Corwin Press.

Haring-Smith, T. (2006). Creativity research review: Some lessons for higher education. *Peer Review, 8*(2), 23-27.

Hatano, G. (1982). Cognitive consequences of practice in culture specific procedural skills. *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 4*(1), 15-18.

Hatano, G., & Inagaki, K. (1986). Two courses of expertise. In H. W. Stevenson, H. Azuma & K. Hakuta (Eds.), *Child development and education in japan.* (pp. 262-272) New York, NY, US: W H Freeman/Times Books/ Henry Holt & Co.

Hatano, G., & Inagaki, K. (1992). Desituating cognition through the construction of conceptual knowledge. In P. Light, & G. Butterworth (Eds.), *Context and cognition: Ways of learning and knowing.* (pp. 115-133) Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Hatano, G., & Oura, Y. (2003). Commentary: Reconceptualizing school learning using insight from expertise research. *Educational Researcher, 32*(8), 26-29.

Kampylis, P., Berki, E., & Saariluoma, P. (2009). In-service and prospective teachers' conceptions of creativity. *Thinking Skills and Creativity, 4*(1), 15-29.

Karpicke, J. D., & Roediger, H. L.,III. (2008). The critical importance of retrieval for learning. *Science, 319*(5865), 966-968.

Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four c model of creativity. *Review of General Psychology, 13*(1), 1-12.

Kozbelt, A., Beghetto, R. A., & Runco, M. A. (2010). Theories of creativity. In R. J. Sternberg (Ed.), *The cambridge handbook of creativity.* (pp. 20-47). New York, NY US: Cambridge University Press.

Limb, C. J., & Braun, A. R. (2008). Neural substrates of spontaneous musical performance: An fMRI study of jazz improvisation. *PLoS ONE, 3*(2), 1-9.

Lonergan, D. C., Scott, G. M., & Mumford, M. D. (2004). Evaluative aspects of creative thought: Effects of appraisal and revision standards. *Creativity Research Journal, 16*(2), 231-246.

Meadow, A., Parnes, S. J., & Reese, H. (1959). Influence of brainstorming instructions and problem sequence on a creative problem solving test. *Journal of Applied Psychology*, *43*(6), 413-416.

Mullen, B., Johnson, C., & Salas, E. (1991). Productivity loss in brainstorming groups: A meta-analytic integration. *Basic & Applied Social Psychology*, *12*(1), 3-23.

Oura, Y., & Hatano, G. (2001). The constitution of general and specific mental models of other people. *Human Development (0018716X), 44*(2), 144-159.

Paulus, P. B., Dzindolet, M. T., Poletes, G., & Camacho, L. M. (1993). Perception of performance in group brainstorming: The illusion of group productivity. *Personality and Social Psychology Bulletin, 19*(1), 78-89.

Plucker, J. A., & Beghetto, R. A. (2004). Why creativity is domain general, why it looks domain specific, and why the distinction does not matter. In J. L. Singer (Ed.), *Creativity: From* *potential to realization.* (pp. 153-167). Washington, DC US: American Psychological Association.

Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan, 42*(7), pp. 305-310.

Richards, R. (2007). Everyday creativity: Our hidden potential. In R. Richards, & R. Richards (Eds.), *Everyday creativity and new views of human nature: Psychological, social, and spiritual perspectives* (pp. 25-53). Washington, DC US: American Psychological Association.

Rinne, L., Gregory, E., Yarmolinskaya, J., & Hardiman, M. (2011). Why arts integration improves long-term retention of content. *Mind, Brain, and Education, 5*(2), 89-96.

Robinson, K. (2001). *Out of our minds: Learning to be creative*. Oxford: Capstone Ltd.

Rotherham, A. J., & Willingham, D. (2009). 21st century skills: The challenges ahead. *Educational Leadership, 67*(1), 16.

Runco, M. A. (2004). Creativity. *Annual Review of Psychology, 55,* 657-687.

Sawyer, R. K. (2006). Educating for innovation. *Thinking Skills and Creativity, 1*(1), 41-48.

Sawyer, R. K., & Berson, S. (2004). Study group discourse: How external representations affect collaborative conversation. *Linguistics and Education, 15*(4), 387-412.

Schacter, J., Thum, Y.M., & Zifkin, D. (2006). How much does creative teaching enhance elementary school students' achievement? *Journal of Creative Behavior, 40(1),* 47-72.

Schwartz, D. L., Bransford, J. D., & Sears, D. (2005). *Efficiency and innovation in transfer*. In J. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective* (pp. 1-51). Greenwich, CT: Information Age Publishing.

Scott, G., Leritz, L. E., & Mumford, M. D. (2004). The effectiveness of creativity training: A quantitative review. *Creativity Research Journal, 16*(4), 361-388.

Simonton, D. K. (1994). *Greatness: Who makes history and why*. New York: Guilford Press.

Sternberg, R. J. (2005). Creativity or creativities? *International Journal of Human-Computer Studies, 63*(4-5), 370-382.

Storm, B. C., & Angello, G. (2010). Overcoming fixation. *Psychological Science, 21*(9), 1263-1265.

Torrance, E. P. (1974). *Norms and technical manual for the torrance tests of creative thinking*. Bensenville, IL: Scholastic Testing Service.

Warren, T. F., & Davis, G. A. (1969). Techniques for creative thinking: An empirical comparison of three methods. *Psychological Reports, 25*(1), 207-214.

Weisberg, R. W. (2006). Expertise and reason in creative thinking: Evidence from case studies and the laboratory. In J. Baer (Ed.), *Creativity and reason in cognitive development.* (pp. 7-42). New York, NY US: Cambridge University Press.

Zabelina, D. L., & Robinson, M. D. (2010). Creativity as flexible cognitive control. *Psychology of Aesthetics, Creativity, and the Arts, 4*(3), 136-143.