Pearson

Skills for Today:

What We Know about Teaching and Assessing Creativity

Illustration by Lucy Vigrass

Written by

Emily R. Lai

Jessica Yarbro

Kristen DiCerbo

Els de Geest

P21 PARTNERSHIP FOR 21ST CENTURY LEARNING

About the Authors

Dr. Els de Geest worked as Director of Pedagogical Models Research within the Learning Research and Design Team, leading on research concerning instruction design, professional development of instructors and effective pedagogy. Her passion is to put research into teaching practice and teaching practice into research. She previously worked as a mathematics teacher in the UK, researcher at the University of Oxford, academic at the Open University and education consultant. She currently works as an international education consultant advising institutions, companies, governments and their agencies on using and implementing effective pedagogies and instruction design at scale. She holds a Ph.D. in mathematics education, a general degree majoring in social sciences, a mathematics degree and a postgraduate teaching qualification, all gained through the Open University in the UK.

Dr. Kristen DiCerbo is Vice President of Education Research at Pearson. She leads a team of researchers focused on conducting and translating research about learners and learning in order to influence the development of curricula and digital tools. Her personal research program centers on interactive technologies, particularly the use of evidence from learner activity in games and simulations, to understand what learners know and can do. Prior to joining Pearson, Kristen provided research support to the networking academies at Cisco and was a school psychologist in a local school district in Arizona. Kristen received her master's degree and Ph.D. in educational psychology at Arizona State University.

Dr. Emily Lai is Director of Formative Assessment and Feedback and part of the Education Research team at Pearson. In that capacity, she leads a research agenda around assessment for learning and principles of effective feedback, particularly within digital environments. Her interests include principled assessment design approaches, such as Evidence Centered Design, performance assessment, and assessment of twenty-first-century competencies. Emily holds a Ph.D. in educational measurement and statistics from the University of Iowa, a master's degree in library and information science from the University of Iowa, and a master's degree in political science from Emory University.

Dr. Jessica Yarbro is a Research Scientist in knowledge and skills within the Learning Research and Design team at Pearson. Through empirical studies and synthesizing existing research, Jessica supports the development of knowledge and skills frameworks within Pearson products. Jessica is particularly interested in the definition and assessment of twenty-first-century skills. Jessica received her master's degree and Ph.D. in clinical psychology from George Mason University.

About Pearson

Pearson is the world's leading learning company. Our education business combines 150 years of experience in publishing with the latest learning technology and online support. We serve learners of all ages around the globe, employing 45,000 people in more than seventy countries, helping people to learn whatever, whenever and however they choose. Whether it's designing qualifications in the UK, supporting colleges in the United States, training school leaders in the Middle East or helping students in China learn English, we aim to help people make progress in their lives through learning.

About P21

P21 recognizes that all learners need educational experiences in school and beyond, from cradle to career, to build knowledge and skills for success in a globally and digitally interconnected world. Representing over 5 million members of the global workforce, P21 is a catalyst organization uniting business, government and education leaders from the United States and abroad to advance evidence-based education policy and practice and to make innovative teaching and learning a reality for all.

Introduction to the Series

This paper is the fourth in a series to be jointly released by Pearson and P21 entitled, "Skills for Today." Each paper summarizes what is currently known about teaching and assessing one of the four Cs: collaboration, critical thinking, creativity, and communication. Our partnership on this series signifies a commitment to helping educators, policy-makers, and employers understand how best to support students in developing the skills needed to succeed in college, career, and life.

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Foreword

Creativity is widely understood as the ability to produce novel and useful ideas—ideas that not only are original and make a unique contribution to the field but also serve some purpose or fulfill some need. The need for creativity in the world of work transcends so-called "creative fields" such as the performing arts or architecture: Nearly every profession can benefit from the infusion of fresh and relevant ideas. In fact, Dave recently practiced his creative skills on the job by designing a new P21 conference and developing new programs with international partners. And Leah similarly uses her creative thinking at Pearson to build unique and effective learning solutions for students, teachers, and schools.

Although ultimately one's creative achievements must be judged by their novelty and utility, research has uncovered other factors that can contribute to a person's creative potential. Such factors include intrinsic motivation to engage in creative tasks, domain knowledge and experience, a facility for unconventional thinking, a particular set of personality characteristics (like openness to taking intellectual risks), and a supportive social environment, whether at home, at school, or on the job.

Though only a small number of people may reach the highest levels of creativity in their lifetime, creativity is a continuum, and we believe that anyone can improve their creative-thinking skills. Teaching approaches that focus on cognitive strategies for problem-solving and divergent thinking show promise in developing aspects of creative thinking. Other techniques include cooperative or collaborative learning, observational learning, improvisation, role-playing games, and some types of diversity training that focus on breaking down stereotypes and challenging assumptions. Although assessment of creativity is still a controversial topic, approaches to assessing creativity, such as measures of divergent thinking ability, evaluation of creative products, and self-ratings of creative ability have a long history. Divergent-thinking tasks appear to do a good job predicting long-term, real-world creative achievements, and raters who have been trained to use creativity rubrics can arrive at a consensus on the creative value of work products within a given domain.

This summary of the research on creativity completes a series of four papers on the four Cs: collaboration, critical thinking, communication, and creativity. Given the continued evolution of economic, social, and environmental problems facing future generations, the ability to craft unconventional solutions will only grow in importance. Pearson and P21 are committed to exploring how to support educators responsible for cultivating their students' creativity and other personal and social capabilities as they move from K-12 to college and beyond.

Image by Aniruddha Mahanta

Introduction

There is a long-standing fascination with creativity and creative individuals, beginning with the Greek philosophers, who wrote about the role of the creative Muse as a form of mystical inspiration (Sternberg & Lubart, 1999). Through the ages, such cultural and academic luminaries as Shakespeare and Freud have also tackled the subject of creativity. The fact that creativity and creative thinking are still prominent in frameworks for twenty-first-century skills is a testament to their continued relevance (e.g., Griffin, McGaw, & Care, 2012; Pellegrino & Hilton, 2012; Trilling & Fadel, 2009). The P21 Framework for 21st Century Learning (http://www.p21.org/our-work/p21-framework) includes creativity as one of the four Cs, along with collaboration, critical thinking, and communication. Although creativity is most commonly understood as the ability to produce works that are both novel and useful (Plucker, Beghetto, & Dow, 2004), as we will see, there are a variety of approaches to defining creativity.

As the types of social, economic, and scientific problems humans face continue to evolve—ranging from climate change to new concerns about privacy and security precipitated by the rise of digital data—creative thinking will continue to be an important skill for future generations. As noted in the World Economic Forum's 2016 report, *The Future of Jobs*, the pace of scientific, technological, and engineering innovation has accelerated in recent years in response to these challenges, giving rise to what the authors dub "the fourth Industrial Revolution" (p. 7). Thus, creativity may provide the raw materials needed to tackle society's biggest problems.

It is not clear whether being more creative leads to more success in school. Creativity may not always be rewarded in the classroom, because the personality attributes most associated with creativity—independent thinking, nonconformity, and openness to risks—are not necessarily valued by teachers (Westby & Dawson, 1995). Likewise, Beghetto (2007) found that prospective teachers tended to prefer student responses that were relevant rather than unique.

A string of empirical studies investigating the link between creativity and academic achievement found varied results, depending on the measures used. For example, Schacter, Thum, and Zifkin (2006) concluded that elementary teachers who were observed as successfully eliciting students' creativity tended to demonstrate larger annual classroom gains in reading, language, and mathematics achievement than their counterparts who did not teach for creativity. Bahar and Maker (2011) found a relationship between performance on both well- and ill-defined math problems scored in terms of fluency, flexibility, originality, and elaboration and performance on standardized math achievement measures. And Gajda, Karwowski, and Beghetto (2016) conducted a meta-analysis of 120 studies examining the relationship between creativity and academic achievement, finding an overall effect size of 0.22. In their analysis, effects were stronger when published tests of creativity and standardized achievement measures were used. On the other hand, Ai (1999) found the opposite: Teachers' ratings of students' creativity were positively correlated with student self-ratings of academic achievement across six domains, whereas published measures of creativity bore no such relationship to academic performance.

Because many of the research designs used in these studies entail looking at concurrent measures of creativity and achievement rather than at measures taken during different time periods, the direction of the relationship is also unclear. For example, does achievement in a domain enable creativity or does being creative help lead to later achievement?

Despite uncertainty about whether creativity leads to academic achievement, there is clear evidence that creativity is in high demand by employers. Several recent surveys and interviews of executives and human-resources professionals in companies within many sectors and in multiple countries indicate that creativity skills are among the most important skills for employees, and the importance of employee creativity is expected to grow in the future. For example, in one survey, more than 63 percent of managers and executives agreed or strongly agreed that creativity and innovation would be priorities for employee development, talent management, and succession planning during the next one to three years (American Management Association [AMA], 2012). Similarly, 72 percent of global senior executives responded in a survey that innovation was a top priority for their company, representing an increase from 64 percent only one year earlier (Andrew, Manget, Michael, Taylor, & Zablit, 2010). In another survey, 81 percent of respondents indicated that creativity and innovation were necessary for four-year college graduates to succeed in the workforce, with nearly 74 percent saying the importance of these skills will increase in the future (Casner-Lotto & Barrington, 2006).

And there is evidence to suggest that the creativity skills of workers benefit their employers. For example, Amabile (1988) found that individual employee creativity is linked to organizational innovation. Work teams that engage in more creative practices have higher performance than teams that engage in more standardized practices (Gilson, Mathieu, Shalley, & Ruddy, 2005). In a global survey of executives, 84 percent said they consider innovation a critical mechanism for economic recovery (Andrew et al., 2010). IBM Institute for Business Value (2016) funded a study involving interviews with over 5,000 CEOs from nineteen different industries worldwide, finding that the most financially successful firms in their sample had CEOs who established a culture of innovation that encouraged employee creativity.

Despite its importance, there may be a creativity skills gap in the workforce. In one survey of managers, more than half of respondents rated their employees as only average at best on the four Cs, although the number of managers who rated their employees as above average in creativity did increase slightly from 37 percent in 2010 to 39 percent in 2012 (AMA, 2012). Four-year college graduates appear to have an advantage over two-year college and high-school graduates in creativity skills, although the number of employers who rated these grads as "excellent" in creativity was still only 21 percent (Casner-Lotto & Barrington, 2006).

It is important to distinguish individual creativity from innovation. As Amabile (2012, p. 3) explains, creativity "is the production of a novel and appropriate response, product, or solution to an open-ended task." On the other hand, innovation is a term often used in a business context to refer to the successful application of creativity within an organization. Innovation requires implementing a creative idea and bringing it to fruition, despite organizational constraints and challenges. Thus, innovation occurs within an organizational environment and requires a host of other skills in order to materialize—skills such as perseverance, a willingness to take risks, social skills, and good communication (Amabile, 1988). In this paper, we will focus on individual creativity rather than the broader concept of innovation, although several factors argued to help create a classroom environment supportive of creativity are the same as those that are mentioned in the literature on organizational innovation, such as autonomy, low stakes for making mistakes, and opportunities for collaboration and playfulness.

In the remainder of this paper, we will attempt to synthesize a number of contemporary theories and models of creativity. Then we will review research on methods for teaching creativity skills in K-12 and higher-education settings. We will end with a summary of different approaches to assessing creativity, from which we will develop a set of recommendations.

Definitions and Models

Kaufman and Beghetto (2009) trace the rise of modern creativity research to a 1950 presidential address by J. P. Guilford to the American Psychological Association in which he argued for the need for more and better creativity research. Since that time, there have been hundreds of publications on creativity. Several relatively recent comprehensive reviews of the creativity literature exist (e.g., Ferrari, Cachia, & Punie, 2009; Kozbelt, Beghetto, & Runco, 2010). It is not the purpose of this paper to recreate those reviews. Rather, our aim is to give the reader a sense of the primary contours of contemporary theories of creativity and to note common areas of overlap in terms of the components included within those creativity models.

SYNTHESIS OF EXISTING THEORIES AND MODELS

Some of the earliest work in the area of creativity research focused on studying creative individuals, where the focus has primarily been on eminently creative people in fields such as music, science, and art (Sternberg & Lubart, 1999). Eminent creators are those whose creative achievements are publicly recognized over time as having moved the field forward in some way. Early approaches to studying creativity involved biographical methods, detailing the backgrounds and life stories of eminent creators so as to identify the critical factors contributing to their creative success (Albert & Runco, 1999). Both the methods and the focus of creativity research have expanded considerably since then. For example, Kozbelt et al. (2010) have organized contemporary creativity theories and models within ten different categories:

1. Developmental theories are those that study the development of creativity over time, focusing on the interaction of people and their environments and characterized by the close biographical study of eminent creators.
2. Psychometric theories conceptualize the definition of creativity in terms of how it can be measured and reliably distinguished from related constructs.
3. Economic theories focus on costs and benefits of creativity for society, as well as market forces that affect creative expression.
4. Stage and process theories outline stages or steps in the creative process.
5. Cognitive theories articulate specific cognitive processes, strategies, and heuristics that spur ideation and elaboration.
6. Problem-solving and expertise theories stipulate that creativity is the result of domain expertise applied to ill-defined problem-solving.
7. Problem-finding theories focus on the creative process, particularly the subjective experience of the creator in understanding their motivation to create.
8. Evolutionary theories explain creative achievements as the result of evolutionary forces, such as blind generation and selective attention.
9. Typological theories approach the study of eminent creators by contrasting creative types defined by their working styles (e.g., seekers versus finders).
10. Systems theories situate creators within complex systems and view creative achievements as the outputs of a complex interplay between components within that system, including environmental factors, the state of the field or discipline, and a person's domain knowledge.

In the years following Guilford's address, a number of prominent creativity theories have gained traction. We review here only a sample of some widely cited creativity models.

One of the most enduring theories associated with creativity is the model of divergent thinking, which Guilford (1950) popularized, but which has since been adapted to become the framework for the well-known Torrance Tests of Creative Thinking (TTCT). Divergent thinking is generally understood as a composite idea-generation skill. The original model of divergent thinking captured in the Torrance tests comprised four subskills:

1. fluency—the ability to generate many ideas;
2. flexibility—the ability to move fluidly between different representations;
3. originality—the ability to produce novel and unusual ideas;
4. elaboration—the ability to fully develop ideas.

The scoring criteria were later refined to exclude flexibility and include abstractness of titles and resistance to premature closure (Kim, 2006). Runco and Acar (2012) have emphasized that divergent thinking should not be confused with creativity; it is only part of the creative process, which must also include evaluation of ideas if they are to have any value. Rather, divergent thinking should be viewed as an indicator of creative potential.

Amabile (1988, p. 126) initially defined creativity as "the production of novel and useful ideas by an individual or small group of individuals working together," and later (2012, p. 3) as "the production of a novel and appropriate response, product, or solution to an open-ended task." Amabile's (1988, 2012) componential model of creativity identifies four main components of creativity:

1. domain-relevant skills, which include factual knowledge and technical skills;
2. creativity-relevant processes, which Amabile defines as cognitive styles related to taking new perspectives, as well as aspects of personality such as a tolerance for ambiguity and risk-acceptance, plus heuristics for ideation and divergent thinking;
3. intrinsic task motivation;
4. the social environment in which the creative process is taking place, including any extrinsic motivators, organizational norms, or constraints that may operate against the individual.

According to Amabile, it is the confluence of these factors that determines whether creativity will emerge.

Similarly, Csikszentmihalyi (2014), although not offering a definition of creativity per se, locates it at the intersection of three systems:

1. the field in which the creative accomplishment must be judged, whose members act as gatekeepers for the domain;
2. the cultural domain, which will be responsible for taking up and preserving creative ideas for future generations;
3. the individual responsible for generating the creative ideas (including motivational, affective, and cognitive factors).

Creativity is, then, the interaction of these three systems because, as Csikszentmihalyi (2014) argues, no creative achievement can be interpreted or judged in a vacuum. Rather, the historical and social context in which the achievement is received must be taken into account in order to render a judgment about its value (originality, usefulness). Whether any given achievement stands the test of time depends on the complex and recursive relationships between field, domain, and individual.

The investment theory of creativity (Sternberg & Lubart, 1992; Sternberg, 2006) begins with the premise that creative individuals "buy low and sell high" in terms of creative ideas. This means that creators take on unknown or unpopular ideas that show growth potential and push them forward until they become accepted. At that point, the creator "sells high," moving on to another idea. Similar to the work of Amabile and Csikszentmihalyi, the investment theory proposes that creativity occurs within the interactions of a number of factors:

- intellectual abilities or "creative intelligence," including the ability to synthesize (by which Sternberg (2006) means break the bonds of conventional thinking), analyze the values of one's ideas to decide which are worth pursuing, and persuade others (which he terms "practical-conceptual" skills);
- knowledge about the domain or discipline, although Sternberg cautions that the Goldilocks principle applies here—some knowledge of the domain is necessary to generate insights, but too much knowledge can make thinking rigid rather than flexible;
- thinking styles, or "preferred ways of using one's skills," including "a preference for thinking and a decision to think in new ways" (Sternberg, 2006, p. 89);
- personality attributes, such as a tolerance for risks and ambiguity, self-efficacy and perseverance;
- intrinsic motivation to engage in the creative task;
- an environment that supports the creative individual.

Sternberg (2006) argues that creativity is more than the simple sum of these elements: There may be thresholds for some factors, below which creativity does not emerge; some factors may compensate for others; or there may be interactions among the factors. Finally, Sternberg emphasizes that being creative is the result of a conscious decision to be creative and that creative contributions must always be judged in the social and historical contexts in which they were produced.

Runco's (1996, p. 4) interpretive definition of personal creativity paints it as a multidimensional composite, defining it "as manifested in the intentions and motivation to transform the objective world into original interpretations, coupled with the ability to decide when this is useful and when it is not." In Runco's view, personal creativity ultimately involves some kind of transformation that takes place when a person interprets their experiences. As such, it is inherently subjective and reliant on the perception of the individual. This type of transformation can encompass not only problem-solving but also problem-finding and articulation. The expression of personal creativity thus depends on:

- motivation;
- certain cognitive styles (interest in novelty, information-seeking, and tolerance for ambiguity);
- metaphoric logic, or an aptitude for unconventional ways of thinking;

- discretion, or "mindful choice," about what and how to transform, in an effort to ensure the transformation has utility and value;
- the intention to create, and the use of processes, strategies, and heuristics to support that intention;
- relevant domain knowledge and experience.

Finally, Simonton's (1997) Darwinian model of creativity argues that creativity follows an evolutionary pattern of blind variation and selective retention. In other words, the creative individual combines ideas in essentially random and unpredictable ways to generate a number of creative potentials (ideation process) and then selects the most promising to develop more fully (elaboration process). Simonton emphasizes that selection happens at multiple levels—both within the individual creator and within the domain, because any creation must be evaluated in relation to the competing creations of others in the same discipline at that specific point in time. Finally, there is a further component of selection in terms of which creations withstand the test of time within a field. Simonton argues that creative productivity is a function of one's career age, or longevity in the field. People begin with some level of initial creative potential, after which their productivity at any point during their career will depend on the amount of potential remaining, the number of ideas that have been identified but not fully developed, and the number of finished creative products. Thus, his model suggests that creative productivity in a number of fields tends to begin in one's twenties, increase rapidly, peak during a person's late thirties or early forties, and then steadily decline thereafter.

Elements held in common across these various theories and models include intrinsic motivation to engage in creative tasks, domain knowledge and experience, certain cognitive styles related to unconventional thinking, a particular set of personality characteristics, and a supportive social environment (which can include a person's home and family life, the classroom environment, and the broader social context). Each of these elements can be seen as a supporting factor for creative expression but does not necessarily constitute part of the creative construct. The difficulty in trying to synthesize these models, as Kaufman and Beghetto (2009) noted, is that there are so many different ways to talk about creativity. For example, Plucker et al. (2004) surveyed ninety different papers with the word "creativity" in the title but found that only 38 percent of them provided an explicit definition of creativity. From our perspective, another challenge in defining creativity is that many of the popular so-called "confluence" models of creativity paint it as a complicated intersection of person, domain, and environmental factors. Although intrinsic motivation, cognitive styles, personality characteristics, and the educational and social environments in which people work appear to be important prerequisites for creative expression (and may be open to influence by parents and educators), they seem to relate to creative potential rather than creativity itself.

Table 1 summarizes the components of creativity, organizing them into two groups: those associated with creative potential and the aspects of creative achievements that define creative production.

Creative Potential	Intrinsic motivation for creative tasks
	Domain knowledge/experience
	Unconventional or divergent thinking
	Personality characteristics (e.g., preference for ambiguity, risk acceptance)
Creative Production	Novelty or uniqueness
	Relevance, utility, or appropriateness for some purpose

Table 1 Summary of creativity components.

Creativity in Practice

At Feaster Charter School, Heather Walker and her colleagues are helping students develop creativity skills using innovative, learner-centered activities. During the engineering and design process students:

- ask a question that demonstrates a problem related to academic learning;
- imagine a solution or answer to the question;
- plan a design for a prototype;
- create a prototype;
- evaluate the prototype;
- improve upon the original design.

This process is mirrored in science classes. Ms. Walker provided the example of a learning activity around "human impact on the environment." After the teacher provides a lesson about related topics, including types of pollution and humans' use of natural resources, students engage in a problem-solving activity. Students identify a problem that could be resolved using technology or the creation of a new product and work through the following steps:

- ask a question (e.g., How can carbon gases be reduced?);
- imagine a solution to their problem;
- plan their design;
- create their prototype;
- evaluate it;
- reflect on what worked and what did not in order to improve upon their original design.

This design process is circular because students can continuously go back and adjust their work as needed. The circular nature of this process encourages self-evaluation. As students improve and redesign their prototype, they continually reflect on their creative growth. Creativity is also fostered by teachers at Feaster Charter School as they encourage students to connect their learning in different areas to improve their solutions. In the example science lesson, students use what they know about technology, engineering, and math while incorporating their artistic skills to design and create a product that would resolve the original science problem. Students also recognize that there is not one set solution to their original question; they demonstrate their creativity by creating a unique solution or multiple solutions for the same problem.

Creativity Continuum

There are at least two frameworks that can guide thinking around what a continuum of creativity might look like.

Kaufman and Beghetto (2009) describe a kind of developmental progression of creative achievement over the lifespan. This progression also supports thinking about assessment of creativity or creative potential of individuals in various stages of development. At the nascent stages of development, creative potential takes the form of what the authors call "mini-c," defined as "novel and personally meaningful interpretation of experiences, actions, and events" (Kaufman & Beghetto, 2009, p. 3). This closely aligns with what Runco (1996) referred to as "personal creativity," and describes what students who are learning something new for the first time experience. For example, a student who has generated her own strategy for adding two-digit numbers may not have made a new mathematical discovery, but because the idea is novel for her and useful in problem-solving, it constitutes mini-c-level creativity.

With practice, support, and feedback from more experienced others, this person may go on to reach little-c-level creativity in mathematics, continuing to engage in creative activities such as coming up with new ways of showing her computation through pictures or other graphical representations as opposed to numeric ones. If mathematics becomes an area of interest for this person, after extensive training, mentoring, and possibly completing advanced degrees in mathematics, she may reach pro-c level. This level describes creators who have reached professional-level status in their domain and are capable of producing creative achievements that earn some recognition in the field, such as publishing a paper or winning a career award.

Finally, a few members of each domain whose creative achievements make lasting impressions to their field may eventually (even posthumously) be recognized as having reached big-c-level status, or eminent-creativity status. These are members of the field who have won prestigious awards (e.g., the Fields Medal in Mathematics, or a Nobel Prize) for their contributions, which stand the test of time.

As Kaufman and Beghetto (2009) explain, mini-c and little-c levels are quite accessible to almost anyone and are more focused on the use of creative processes and behaviors than on producing tangible creative achievements. On the other hand, pro-c and big-c are primarily about the quantity and quality of creative products.

This framework has implications for assessing creativity among individuals at various stages: because the first two are focused primarily on process, the authors recommend self-assessment and think-aloud strategies that make

Teachers at Feaster Charter School also recognize the importance of classroom culture. Students are better able to explore and develop skills in creativity when the voice and choice of each individual student is recognized. Teachers structure the classroom so that students have flexible seating choices, a maker's space, and materials to create engineering projects. Collaboration and continuous reflection are also encouraged so students have the opportunity to create, not just consume information.

creative processes visible. On the other hand, because the latter two stages are concerned with creative contributions, assessment can focus on evaluation of the quantity and quality of creative achievements, particularly the nature of their contribution to the field in terms of novelty and utility.

Sternberg, Kaufman, and Pretz (2001) provide a useful way of categorizing the contribution of creative achievements in a given domain. According to the authors, products are generally evaluated against the twin criteria of originality and fit for purpose (or novelty and utility). The propulsion model of creative contributions is so-called because creative achievements typically attempt to propel the field forward in some way; thus, they can be judged by the nature of that propulsion. The authors describe eight different types of achievements, which vary by the extent of the propulsion:

1. replication (as one would guess, this type of achievement does not propel the field but rather maintains its current position);
2. redefinition (reconceptualizes where the field currently is);
3. forward incrementation (a small step forward for the field, in the same direction it was already going);
4. advance forward incrementation (a larger leap forward, although still in the same direction it was already going);
5. redirection (moves the field from its current direction to a new direction);
6. reconstruction/redirection (takes the field back to a previous position so that it can proceed forward in a different direction);
7. reinitiation (propels the field toward a new, not-yet-reached starting point, coupled with a change in direction);
8. integration (ties together two previously disconnected and even opposing viewpoints, creations, or approaches to formulate a new paradigm).

Together, these frameworks provide a way of conceptualizing development of creative abilities over the life span and evaluation of creative potential or achievements at any given stage of development.

Domain Specificity

Although almost no one debates the importance of domain knowledge in supporting creative achievement, there is a question as to whether creativity is a set of generic skills that can be applied in any domain, whether it is completely specific to a particular discipline or domain, or whether there are some aspects that are relatively domain-general and other aspects that are domain-specific.

On the one hand, many researchers have noted that it is extremely rare to reach eminent-creative status in more than one domain, which suggests that at least some aspects of creativity are domain-dependent. In addition, researchers have found that student scores on creative products across multiple domains (e.g., mathematics, writing, art) tend to be relatively uncorrelated with one another (Baer, 1998; Han &

Marvin, 2002). On the other hand, there may be cognitive strategies or heuristics for divergent or unconventional thinking (e.g., thinking backwards, questioning assumptions) that can be learned and usefully applied in multiple domains. And certain personality attributes that support creativity (tolerance for ambiguity, risk-acceptance, openness to experience) may be relatively stable across domains.

The most reasonable position, therefore, may be that creativity is both domain-general and domain-specific. Kaufman and Beghetto (2009) even suggest that the importance of the domain may vary over the life span depending on what stage of creative development the person is working on, with the particular domain less important for beginning creators, who are focusing on developing creative processes. The domain becomes more important as the creator develops, however, with domain expertise becoming almost indistinguishable from creative achievement at the pro-c and big-c levels, which are more focused on producing and refining creative contributions.

Creativity in Practice

In a 2010 survey by IBM, CEOs indicated that creativity was the principal skill they were looking for when hiring college graduates. In response to these findings, faculty members at Eastern Kentucky University (EKU) designed and launched a new minor in Applied Creative Thinking. As the program director for the minor in Applied Creative Thinking and a course instructor within the minor, Dr. Russell Carpenter has played a key role providing students at EKU with a foundation in creative-thinking skills.

In designing the minor, Dr. Carpenter and his colleagues faced a fundamental challenge: How do you translate creative techniques from specific fields such as the creative arts and engineering into general strategies that can be applied to any major or career? This question led to the development of a set of creative-thinking skills, including piggybacking, brainstorming, glimmer-catching, and shifting perceptions, which form the foundation of EKU's minor. The minor is intentionally designed around applying three phases of learning to these skills: observation, application, and production. This organization allows for a scaffolded process where students take on increasing responsibility and control within the creative process. Students begin with Introduction to Creative Thinking where they learn the language of creativity. Students learn specific creative-thinking skills and, through working with these terms, develop a nuanced understanding of creativity.

Students then progress to the application of creative-thinking skills, which is exemplified in the Innovation and Creativity course. This course frequently involves hands-on creative work applying different skills. In one activity, Dr. Carpenter presented students with the problem of how to improve snow removal at their university. Students then engaged in creative problem-solving, using everyday objects such as crayons and rubber bands to devise solutions. Students utilized the strategy of shifting perceptions to think deeply about the objects and how they could function in new and innovative ways. Collaboration is used intentionally to enhance the creative process. Group work supports the use of piggybacking, where students expand and build upon each others' ideas. Dr. Carpenter describes this activity as helping students "look at the ordinary in extraordinary ways." These activities are designed to challenge students, which is instrumental to the learning process. Creative production is often about pushing boundaries, and these activities help students become comfortable with this process. In the minor's capstone course, students engage in creative production, with the ultimate goal of generating change. Students work with community and campus partners to apply the creative process in a real-world setting.

Courses within the minor often incorporate reflection. Students construct creativity narratives where they describe the evolution of their creativity skills, and portfolios are used to track the development of creative artifacts. These self-reflections serve to assess student progress and support future learning. By critically examining their past work, students can identify the next steps needed to further develop their creative-thinking skills.

Through instruction, applied activities, community projects, and self-reflection, Dr. Carpenter and his colleagues aim to provide EKU students with the creative-thinking skills needed to drive innovation in their other courses and future careers.

Russell Carpenter, Ph.D., Program Director, Minor in Applied Creative Thinking, Executive Director, Noel Studio for Academic Creativity, Associate Professor of English, Eastern Kentucky University

Teaching Creativity

Introduction

Given the emphasis employers place on creativity skills, it is important to understand how to teach these skills to students. There have been several meta-analyses examining the impact of creativity-focused interventions. In this section, we summarize findings from three of the most recent: Scott, Leritz, and Mumford (2004a, 2004b) and Ma (2006). Overall, these meta-analyses found fairly large, and generally consistent, average effect sizes for creativity interventions: 0.68 (Scott et al., 2004a), 0.77 (Ma, 2006), and 0.78 (Scott et al., 2004b). Scott et al. (2004a) also examined whether interventions were more effective depending on the target outcomes. The largest effect sizes were found in studies targeting problem-solving (0.84; production of original solution to novel problems) and divergent thinking (0.75; fluency, flexibility, originality, elaboration) while smaller effects were found for performance (0.35; generation of creative products) and attitudes and behavior (0.24; reactions to creative ideas, creative efforts initiated). Follow-up analyses revealed program characteristics that were linked to larger effect sizes. More specifically, programs that produced stronger effects employed a cognitive framework (e.g., stressing the cognitive processes by which people work with knowledge to generate ideas), emphasizing the processes of problem-finding/identification, conceptual combination, and idea generation. More effective programs also included real-world practice along with social modeling, cooperative learning, and case-based learning techniques. In contrast, unconstrained exploration was less effective, with techniques such as engaging in expressive activities and imagery producing smaller effects.

While Scott et al. (2004a) examined the association between program characteristics and effect sizes, Ma (2006) determined the effect sizes for various creativity training packages (i.e. those based on a common theoretical framework). Specific training packages, along with their effect sizes, are listed in Table 2. Overall, Ma (2006) found fairly large and consistent effect sizes across training packages (effect sizes ranging from 0.61 to 0.82) with the exception of the New Directions in Creativity Program, which had a much larger effect size (1.41).

TRAINING PACKAGE	DESCRIPTION	EFFECT SIZE	
		M	SD
The New Directions in Creativity Program (Renzulli, 1973)	Based on Guilford's (1967) Structure-of-Intellect Model; contrasts divergent (identifying as many answers or solutions as possible) and convergent (trying to find the best or right answer) thinking	1.41	0.21
Osborn–Parnes Creative Problem-Solving Program (Osborn, 1963; Parnes, 1967)	Provides instruction in four stages of creative problem-solving: (1) identifying and finding problems; (2) generating solutions; (3) evaluating solutions; (4) elaborating on a solution	0.82	0.58
Khatena's Training Program	Involves instruction and practice in five creative thinking strategies: (1) breaking away from the obvious and commonplace, (2) transposition, (3) analogy, (4) restructuring, and (5) synthesis	0.82	0.61
Purdue Creative Thinking Program (Feldhusen, Speedie, & Treffinger, 1971)	Uses twenty-eight audiotaped lessons to support divergent thinking (fluency, flexibility, originality, and elaboration) through instruction, illustrations, and practice	0.63	0.65
Computer-aided creativity training	Includes a combination of computer graphic technology (manipulating text and graphics) as well as Logo computer programming (identifying problems and choosing or combining information, knowledge, and solutions)	0.61	0.23

Table 2 Effect sizes for specific creativity training programs from Ma (2006).

Another meta-analysis by Scott et al. (2004b) used less stringent exclusion criteria in order to determine the relative frequency of different types of creativity interventions. They first utilized a cluster analysis to identify different creativity intervention types based on common features. Imagery training was identified as the most common intervention type. These types of programs "stressed imagery, expressive activities, and imaginative exercises" and used "feedback, instructor encouragement, and unstructured exercises as a basis for training" (Scott et al., 2004b, p. 164). Consistent with Scott et al.'s (2004a) prior findings, these programs had smaller effect sizes (0.43) with a majority (81 percent) of interventions in this cluster rated as unsuccessful. The second most common intervention type was situated idea production training, which "stressed idea generation, divergent thinking, ideation, elaboration, and brainstorming, relying on examples (e.g., cases) while providing a wide variety of classroom exercises intended to illustrate application of idea production techniques in a reasonably realistic fashion" (Scott et al., 2004b, p. 164). Again, consistent with Scott et al. (2004a), these interventions had a relatively high average effect size (0.89).

Taken together, these meta-analyses present a favorable picture of creativity-training programs as a viable option for improving creativity. Creativity-training programs appear most effective when they are targeting creative problem-solving or divergent thinking and provide structured instruction and practice around problem-solving steps. While these meta-analyses include interventions targeted at students, they also survey workplace programs for adults. Given the focus of this paper, in the next sections we review research on teaching creativity in primary and secondary schools and higher-education environments more specifically. Given the sheer volume of creativity-related research, in reviewing the literature, we attempted to limit our search to the following criteria:

- relatively recent studies (i.e. those published within the past twenty years);
- studies that present empirical findings;
- studies that provide a minimum level of description of the actual intervention;
- studies applying at least a single group pretest/posttest design, with a preference for more rigorous research designs, such as experimental and quasi-experimental studies.

Primary and Secondary Schools

We first examine several holistic creativity interventions. Hu et al. (2013) evaluated the Learn To Think (LTT) program, which was designed to develop thinking abilities (including aspects of creative thinking) in primary and secondary students in China. The program is based on the thinking-ability structure model, which includes:

- thinking content (mathematics, language and literature, science, society, art, other disciplines and daily life experience);
- thinking methods (observation, space cognition, comparison, classification, inductive and deductive reasoning, reorganization, brainstorming, transfer, questioning);
- thinking quality (profundity, flexibility, critical thinking, agility, and originality).

LTT has been implemented in more than 300 primary and secondary schools in China, with more than 200,000 students participating over a period of ten years. Hu et al. (2013) examined the impact of LTT on creative problem-solving within a scientific context. The program was conducted in one class of secondary-school students who participated in LTT activities every two weeks over a two-year period.

Another class, which functioned as the control group, did not participate in LTT. All students were twelve years or older. While the two groups did not differ prior to the intervention, six months after the intervention concluded, creative problem-solving scores were significantly higher for students who received the LTT intervention. These results indicate that the LTT program can positively impact the development of scientific creativity in secondary-school students, with fairly long-lasting effects.

Maker, Jo and Muammar (2008) examined the impact of the DISCOVER project on the creativity of elementary-school children. The DISCOVER project is a curriculum and teaching model organized around the following six principles:

1. Integrate multiple intelligences through self-selected product formats, available/accessible tools, and choices based on student interests and strengths;
2. Pose a variety of types of problems and, at times, encourage students to design their own problems;
3. Include collaborative and learner-centered environments with lots of flexibility;
4. Organize content around broad-based, interdisciplinary themes;
5. Model a variety of processes and give students opportunities to practice;
6. Encourage students to develop varied products that reflect the diverse strengths, interests, and preferences of students.

Students demonstrated higher levels of creativity after being in a classroom where the DISCOVER curriculum was more fully implemented. This study provides evidence of an academic curriculum that can foster creativity without taking time away from academic content; however, the lack of random assignment in this study makes us less confident that differences in creativity were entirely due to curriculum implementation.

PROBLEM-SOLVING TRAINING

Based on the meta-analyses, there is fairly compelling evidence for the positive impact of problem-solving training on creativity. In this section, we briefly review problem-solving interventions not already addressed in the meta-analyses. Alfonso-Benlliure, Meléndez, and García-Ballesteros (2013) examined an intervention with young children whose aim was to stimulate creativity at the end of early education (five years old) during six weekly, one-hour training sessions. These sessions taught cognitive problem-solving processes including problem-finding, problem formulation, idea generation, and idea evaluation through games and exercises, including pretend and imaginative play. The study involved two classes of students, one that received the intervention and one that did not. Students receiving the intervention experienced significant gains in creativity exhibited during drawing tasks. It should be noted that groups were established based on existing classes, not random assignment, and it is unclear whether the two groups could be considered equivalent.

In addition, Kurtzberg and Reale (1999) developed a problem-solving intervention for eighth-grade students based on Torrance's Future Problem-Solving (FPS) process (Torrance, 1978). Within the FPS process, individuals are presented with a "fuzzy situation" (i.e. an ill-defined, real-world problem that might be faced by future generations). This intervention focused on the problem-identification step, which involves brainstorming as many problem statements as possible that can be used to understand the fuzzy situation. Within the context of a physical science lesson on solar energy, students were taught strategies for brainstorming and were given lists of potential problem categories to help expand their list of problem statements. The students' problem-identification skills following the intervention were

compared with another class that did not receive the intervention. Problem-identification skills were measured based on the students' responses to other fuzzy situations. Students received scores based on the number of problems identified, number of problems identified that were relevant to the situation (fluency), and number of different problem categories identified (flexibility), along with a total score. Results indicated that the intervention positively impacted all four facets of problem-identification skills. These results are particularly encouraging as a way to integrate creative problem-solving into an academic curriculum. Again, comparisons were based on student classrooms, not random assignment.

OBSERVATIONAL LEARNING AND MODELING

Research has also addressed whether observational learning or exposure to creative models can enhance creativity. Most of this work builds on Bandura's (1986) social learning theory, which suggests that individuals acquire new skills by watching the work of others. Two modeling studies examine creativity as it is manifest through art and design. Anderson and Yates (1999) taught artistic clay work to six-year-old students using social modeling and cognitive learning principles across a six-week period (ninety minutes of instruction per week). During the class, the teacher modeled techniques for working with clay, verbalizing her actions to give students a vocabulary for discussing clay-modeling processes. The class also involved frequent skill practice. The creative-work products (i.e. clay-work designs) of students receiving the modeling intervention were compared to those of students taught using traditional, nondirective curriculum practices. Results indicate that the modeling intervention had a positive impact on technical competence, decorative competence, aesthetic appeal, and three-dimension approximation.

In a similar study, Groenendijk, Janssen, Rijlaarsdam, & van den Bergh (2013) examined the impact of observational learning, compared to direct instruction of strategies, on the design work products of ninth-grade students. Students in both groups were taught the same design steps, which were based on Sapp (1995), a stepwise process for design involving various divergent (producing ideas and sketches) and convergent (evaluating ideas and making choices) stages. In the observational learning condition, students watched videos of other students completing design tasks (e.g., designing a mouse pad). The videos showed work in progress and the model's hands, along with the model thinking aloud through the design steps. In the control group, students were taught and practiced design steps without observing a model. Students in both groups were asked to design products—a pair of bath slippers (at pretest) and a T-shirt (at posttest)—which were rated on novelty and appropriateness as measures of creativity. Students' aptitude (or initial design ability) was included as a moderator. Results show that observational learning had a positive impact on creativity, but only for high-aptitude students. For low-aptitude students, creativity improved equally in both the observational-learning and direct-strategy instruction conditions.

In addition to artistic work products, Yi, Plucker, and Guo (2015) also considered how modeling influenced divergent thinking in a sample of Grade 8 (junior middle school) students. For artistic work products, two groups of students were asked to complete two artistic tasks: creating a collage and drawing an alien. One group viewed creative models for these tasks prior to completing them. Likewise, two other groups were asked to complete verbal and figural divergent-thinking tasks. Again, students in one group were shown creative models prior to completing the task. Exposure to creative models had a positive impact on artistic work products and divergent thinking. More specifically, students who viewed models produced collages and drawings with higher scores on creativity, technical quality, imagination, artistic level, elaboration, and overall impression. Regarding divergent thinking, viewing models positively impacted all three facets of divergent thinking on the verbal tasks (fluency, flexibility, and originality) but not on the figural tasks.

LEARNING ENVIRONMENTS

In addition to specific creativity interventions, we also reviewed research on environments and conditions that enhance creativity in primary- and secondary-school-age children. Davies et al. (2013) conducted a systematic review of the literature on creativity, focusing primarily on research that is qualitative in nature, using a thorough case-study design approach rather than making comparisons to some sort of control group. In their review, Davies et al. (2013, p. 80) identified the following environmental factors as supporting the development of creative skills in students: "flexible use of space and time; availability of appropriate materials; working outside the classroom/school; playful or games-based approaches with a degree of learner autonomy; respectful relationships between teachers and learners; opportunities for peer collaboration; partnerships with outside agencies; awareness of learners' needs; and non-prescriptive planning." We examine each of these factors in turn below.

FLEXIBLE USE OF SPACE AND TIME

Having flexible use of space within the classroom or workshop can promote students' creativity and imagination to support the growth of ideas (Bancroft, Fawcett, & Hay, 2008; Jeffrey, 2006, cited in Davies et al., 2013). For example, not using specifically themed role-play areas and props in early-year settings gave more freedom for the students' imagination (Bancroft et al., 2008). Similar to the flexible use of space, using time flexibly can also play a role in the creativity of students. For example, young students need time for immersion in a creative activity (Burnard, Craft, & Cremin, 2006).

AVAILABILITY OF APPROPRIATE MATERIALS

For learning activities that involve making artifacts, research shows that making a wide range of appropriate materials and tools available to students can enhance their creativity (Gkolia, Brundett, & Switzer, 2009, cited in Davies et al., 2013).

WORKING OUTSIDE THE CLASSROOM OR SCHOOL

Taking students out of school or their classroom can increase their creative skills (Borradaile, 2006; Burgess & Addison, 2007; Dillon, Craft, Best, Rigby, & Simms, 2007; Kendall, Muirfield, White, & Wilkin, 2007; Rutland & Barlex, 2008, cited in Davies et al., 2013). This can take the shape of working in outdoor environments, museums, or galleries. Dillon et al. (2007) speculate that the different ownership of the space might contribute to this; in their research they found that teachers felt ownership of their indoor school space, whereas outdoors both time and space were considered to be more owned by the students.

PLAYFUL APPROACHES WITH A DEGREE OF LEARNER AUTONOMY

The importance of play and playfulness as factors in developing creative skills is highlighted repeatedly in the creativity research literature. Play is informal, allows learner autonomy, allows students to work at their own pace and can blur the distinction between work and play (Cremin, Burnard, & Craft, 2006).

The importance of introducing playfulness in learning through the use of drama learning strategies was demonstrated in two intervention studies in Hong Kong that aimed to enrich creativity in young people (Hui, Chow, Chan, Chui, & Sam, 2015). The first study concerned using arts-enriched Chinese reading in the preschool classroom, integrating creative arts with Chinese reading in fifteen kindergartens in Hong Kong by using linguistic, dance, music, and visual arts inputs to stimulate the curiosity of the children. The eight-week intervention involved 823 students, aged between five and six years old, taking part in the research. The second study used creative drama learning strategies in subjects such as Chinese, English and General Studies with young people aged between four and sixteen. From 2008 to 2013, a total of 2,846 students were recruited. Both studies used pretests and posttests of creativity.

In both studies, gains in different dimensions of creativity were found: figural creativity, verbal creativity, and movement creativity. The authors note that drama techniques appear to have enabled students to play and encouraged exploration and imagination, and that playfulness and arts-enriched learning can improve creative performance.

In another study, Garaigordobil (2006) examined the impact of a play program for ten- to eleven-year-old children. The play program involved weekly, two-hour sessions throughout the school year where students played a variety of games that emphasized cooperation, pretending, and enjoyment. A control group participated in normal school curriculum activities during this time. Results indicated that the program had a positive impact on divergent thinking and drawing creativity, particularly for students with lower levels of creativity at the beginning of the program.

RESPECTFUL RELATIONSHIPS BETWEEN TEACHERS AND LEARNERS

Building good and respectful relationships between teachers and learners is good general practice. Research has also found that having such relationships acts as an enabling factor for creative learning (Menter, 2010).

WORKING COLLABORATIVELY

Working collaboratively with peers can enhance the creativity skills of students (Burgess & Addison, 2007; Dillon et al., 2007; Rutland & Barlex, 2008; Wood & Ashfield, 2008, cited in Davies et al., 2013). Dillon et al. (2007) also suggested that cross-age collaboration was more likely to happen in the outdoors than in the classroom.

PARTNERSHIPS WITH OUTSIDE AGENCIES

Collaboration with outside agencies can enhance the creative learning environment and help in developing creativity skills. For example, in his review of creative learning practices in Europe, Jeffrey (2006) noted that creative events often involve working together with visual artists, dancers, actors, and environmental workers.

In England, the government-sponsored Creative Partnerships program is another example of where partnering with outside agencies can improve the creativity of students. The program involved bringing creative workers, such as artists, architects, and scientists into schools to work with teachers on projects to inspire students. Its aim was to develop the creative skills of children and young people, raising their aspirations, achievements, and life chances. Kendall, Morrison, Yeshanew and Sharp (2008) found in their national evaluation of the program that the academic progress of secondary students taking part in the study was significantly greater than that of similar students nationally.

AWARENESS OF LEARNERS' NEEDS

By developing an awareness of the unique needs of individual learners, including individual strengths and weakness, teachers can support creativity (Bancroft et al., 2008; Burnard et al., 2006; Jeffrey, 2006; Sharp et al., 2006, cited in Davies et al., 2013). Learning environments in which students were encouraged to take an active role in their learning and to share information about themselves with the teacher were associated with creative thinking (Lopez, Esquivel, & Houtz, 1993).

NONPRESCRIPTIVE PLANNING

Research has found a relationship between creativity and classrooms with "less prescriptive" lesson planning, where there was more unstructured time available to pursue students' individual interests and questions (Braund & Campbell, 2010; Cochrane & Cockett, 2007; Jeffrey, 2006; Schacter et al., 2006; Sharp et al., 2006,

cited in Davies et al., 2013). Similarly, Besançon (2006) found that the nontraditional pedagogy of Montessori schools was associated with the development of creativity.

Higher Education

PROBLEM-SOLVING TRAINING

A variety of problem-solving training interventions have been implemented in the higher-education context. One framework that was not evaluated in the meta-analyses is TRIZ (Altshuller, Shulyak, Rodman, & Fedoseev, 1997; Gadd, 2011). The TRIZ acronym is based on a Russian phrase that translates to "theory of inventive problem-solving." As opposed to other, more open-ended problem-solving schemas, TRIZ involves a systematic and scientific approach to solving problems, most often improving technical systems. TRIZ methods focus on identifying difficulties with innovative design that arise from technological constraints and contradictions (i.e. if you increase the weight of a car, you decrease the speed). TRIZ provides a systematic way to analyze what aspects of design are contradictory (and thus present a problem), then recommends inventive rules that might help resolve the contradiction. Examples of these inventive rules include segmentation (divide an object into removable parts) and universality (make a part perform multiple functions).

We consider two studies that examined the impact of TRIZ-based training programs on creativity in engineering undergraduate students. Chang, Chien, Yu, Chu, & Chen (2016) taught a six-week education program titled "Designing and Making Model Solar Cars" to first-year undergraduate engineering students. One group of students was taught problem-solving based on the TRIZ framework, while the control group learned traditional problem-solving steps (e.g., identify problems, analyze problems, propose strategies, select strategy, execute strategy). The main distinction between groups was the analyze-problems step, where students in the TRIZ course identified design contradictions and used the TRIZ inventive rules to work around problems. Students were scored on their creative process (i.e. designing the car) as well as on the creativity of their solar cars. The TRIZ intervention appeared to have a positive impact on the overall creative process, specifically the stages of analyzing problems, proposing strategies, selecting strategies, and executing strategies. Additionally, those in the intervention group produced solar cars that were rated more novel and appropriate or useful.

In another study with undergraduate engineering students, Pitso (2013) used the TRIZ framework to teach students to analyze and improve different types of technology (i.e. water purification, coal-based energy and forestation-driven paper production). The course was taught outside of the credit-bearing coursework, spanning eight sessions across six months. Pitso (2013) employed a single group design, examining students' divergent thinking before and after the course. Results indicated that students' scores increased on all facets of divergent thinking (fluency, flexibility, and originality) following the intervention. These findings are particularly encouraging because the program, which taught inventive problem-solving within a particular domain, appeared to have an impact on a general measure of creativity, suggesting the possibility of transferring creativity strategies from one domain to another; however, due to the lack of a control group, it is not possible to determine whether the improvement in divergent thinking was due to the application of the TRIZ framework or some other factor.

Robbins & Kegley (2010) examined the impact of an online creativity program based on the Thinkertoys book (Michalko, 2006). Participants were undergraduate students, and the intervention was administered either during the first six weeks of a Principles of Management course or as part of a stand-alone free elective course in creative inquiry.

The course taught techniques for approaching challenges and generating solutions in creative ways (i.e. reversing assumptions, dissecting challenges, mind-mapping, imaginative questioning techniques). The course included instruction about the cognitive processes associated with creative thinking as well as authentic assignments designed to help students practice the techniques. Additionally, the course promoted an environment of safety where students felt comfortable taking risks and taught students to defocus their attention through the use of visualization and relaxation techniques. A single groups design was employed, examining the impact of the course on students' verbal divergent thinking. Following the course, students' scores increased on all facets of divergent thinking (fluency, flexibility, and originality), and students reported an increase in their confidence in their creative abilities. Again, due to the lack of a control group as well as the multifaceted nature of the intervention, it is not possible to determine which component of the intervention influenced divergent thinking, or whether the improvement was due to other factors.

Lastly, Cheung, Roskams, and Fisher (2006) taught a thirteen-week credit-bearing course on creativity to undergraduate students. The researchers do not mention a specific training model, but several aspects of the intervention focused on problem-solving. During the first few weeks of the course, the teacher introduced creativity techniques, such as mind-mapping, making nonobvious connections, brainstorming, breaking assumptions, and using analogies. The students then engaged in authentic, multifocused tasks aimed at stimulating creativity, such as designing a minidrama, creating an innovation for the university, generating proposals to solve current local problems, designing a commercial product, and lateral thinking activities. The course often involved group work and asked students to focus and reflect on a variety of ways of approaching and solving problems. Participation in the course was voluntary, and, to determine the impact of the course, the verbal creativity of students attending the course was compared to a sample of students not attending the course. Results indicated that for students attending the course, verbal creativity (as measured by the fluency of idea generation) significantly improved. For students that did not attend the course, verbal creativity was unchanged during the same time period. Additionally, students' creativity during drawing tasks also improved following the course—although this task was not given to the control group. Since participation in the course was voluntary, there is some concern that these findings might not generalize to individuals less interested in creativity.

METACOGNITION TRAINING

Hargrove (2012) developed supplemental instruction for undergraduate design students that focused on enhancing creativity through instruction and practice in metacognitive strategies. Metacognition involves two components: awareness and monitoring of cognition (i.e. thoughts) as well the regulation of cognition. Metacognition is hypothesized to play a role in creative problem-solving. By enabling students to step back and reflect on the problem-solving process, metacognitive strategies allow students to better see new connections and "think outside of the box." First-year design students in a variety of disciplines (i.e. architecture, graphic design, industrial design, and art and design) participated in the study. Students were divided into two equivalent groups based on discipline, gender, and baseline creativity. The control group attended the standard design studio and lecture sequence. In addition to standard instruction, the experimental group also attended a one-hour, weekly seminar during their first spring semester where they learned creative-thinking strategies within a metacognitive framework, such as reverse brainstorming, mind-mapping, idea checklists, and forced connections. A metacognitive framework was also added as students were taught to monitor, reflect on, and evaluate their use of these strategies. During the spring semester of their second year, a subset of the experimental group was also asked to participate in an online blog that served as a metacognitive tool.

This blog provided a framework for students to set goals, monitor, and reflect on their individual design thinking process, and to share this information with other students.

After the first intervention semester, scores on a design thought model assignment were compared between those who did and those who did not receive the intervention. Those receiving the intervention received higher overall scores, as well as higher scores on the metacognitive thinking component. To assess the long-term impacts of this training, outcomes were also measured at the end of the students' undergraduate study (three years after the conclusion of the first intervention and two years after the conclusion of the second). Compared to the control group, students who participated in either one or both of the experimental interventions showed significant gains in divergent thinking ability. This study provides compelling evidence that a combination of problem-solving and metacognitive training can have long-term impacts on divergent thinking.

ROLE-PLAYING GAMES AND IMPROVISATION

One recent avenue of research on creativity involves examining the impact of role-playing and other improvisation games. During role-playing games, participants take on the role of a specific character and, with other characters, work through a game scenario within the bounds of a system of rules and guidelines. The game scenarios often involve solving a problem or working through a conflict and engage participants' imagination, improvisation skills, and cognitive problem-solving skills. Current research focuses on tabletop role-playing games (TRPGs), which means that the game is played with a physical game board as opposed to online. Cross-sectional research by Chung (2013) found that TRPG players had higher divergent thinking scores than non-players.

Intervention research also suggests that playing TRPGs can enhance creativity in new players. Karwowski and Soszynski (2008) evaluated the impact of role-playing training on creativity. Undergraduate participants were taught about imagination, creativity, and visualization and participated in a variety of role-playing exercises. The exercises were structured as games and involved participants solving a problem or developing their own story within the constraints of a game scenario. The eight-hour training was either administered over one day or four weekly sessions. The training had a positive impact on several facets of creativity, including fluency and originality, as assessed through drawing tasks, although the experiment did not include a control group.

Dyson et al. (2016) build on this research using a more rigorous experimental design. The intervention involved four weekly, three-hour role-playing game sessions. Undergraduate participants played through story modules that were designed to encourage cognitive creativity through perspective change, divergent thinking (i.e. the players had to make use of powerful items with strange and nonobvious uses), critical thinking, and problem-solving (i.e. most stories centered around how to solve several problems). Students who did not participate in the games served as a control group. Group assignment was not strictly random as it was partially based on availability. After controlling for initial group differences in divergent thinking, results indicated that playing TRPGs had a positive impact on overall divergent thinking. However, differences on the specific divergent thinking subscales (fluency, flexibility, originality, and elaboration) did not reach significance.

The impact of improvisation and role-playing on divergent thinking has also been analyzed in the context of a creative drama course. Karakelle (2009) taught a ten-week, three hours per week, creative drama course to postgraduate science and math education students. Participation in the course was voluntary, and a control group was constructed of students within the same discipline who did not take the course. The first three sessions focused

on developing group trust and cohesion. The latter seven sessions involved activities promoting self-awareness, awareness of others, self-expression, and spontaneity. Group or individual plays with instructions were utilized in the earlier sessions, while later sessions focused on improvisational role-playing. Participants would develop a skit, rehearse it with improvised dialogue, and then enact it before concluding the session with a group reflection. Results indicated significant gains in both the fluency and flexibility aspects of divergent thinking for students participating in the drama class compared to the control group. It should be noted that, since the course was voluntary, random assignment was not used, and the two comparison groups may not be equivalent.

DIVERSIFYING EXPERIENCES AND STEREOTYPE REDUCTION

Another avenue of research examines whether situations that violate assumptions or stereotypes have an impact on creativity. These experiences may help shake individuals out of their existing knowledge structures, allowing them to approach problems in new and creative ways. In two experiments, Ritter et al. (2012) examined whether "diversifying experiences" increased cognitive flexibility in undergraduate students. In the first experiment, participants were either exposed to unexpected or normal events and experienced these events either through virtual reality (VR) or by watching a video. For the unexpected-events condition, participants viewed a virtual environment where the laws of physics were violated, while the laws of physics were not violated in the normal-events condition. Results indicated that exposure to unexpected events in a VR environment (but not via video) increased participants' cognitive flexibility. In the second experiment, participants encountered an everyday activity (making a sandwich), where the sequence of events was either presented in a typical or an unusual order (schema violation). Groups were also distinguished by whether participants actively made the sandwich or simply watched a video. As in the first experiment, students who were actively engaged in making the sandwich in an unexpected order exhibited the highest levels of cognitive flexibility.

Research also suggests that exposure to stereotype-inconsistent targets (i.e. a female mechanic) can contribute to more divergent and flexible thinking for some individuals. In two studies, Gocłowska and Crisp (2013) and Gocłowska, Baas, Crisp, and De Dreu (2014) asked undergraduate participants to imagine either a stereotype-consistent (male mechanic) or stereotype-inconsistent (female mechanic) individual and describe them. Exposure to stereotype-inconsistent individuals contributed to increased divergent thinking, but only for individuals reporting a low personal need for structure. Gocłowska et al. (2014) found a similar result when inconsistency was presented using visual schemas (i.e. seeing an Inuit in a snowy landscape vs. a desert). The researchers suggest that having a higher need for structure results in a preference for rules, prototypes, and stereotypes, which inhibits the positive effect of stereotype-inconsistent exposure.

Lastly, another avenue of research examines the impact of multicultural experiences on creativity and divergent thinking. In two cross-sectional experiments, Maddux and Galinsky (2009) demonstrated that time spent living and studying abroad was related to an individual's ability to generate creative solutions to insight and interpersonal problems. In another experiment, they manipulated the experience of living abroad through priming. A group of undergraduate students who had previously lived abroad were randomly assigned to one of four conditions. They were asked to imagine and mentally simulate either living abroad, traveling abroad, spending a day in their hometown, or going to the supermarket. Those in the living-abroad condition were best able to identify common elements among divergent topics.

To better understand the mechanism behind this effect, Maddux and Galinksy (2009) conducted another experiment with undergraduate

students who had previously lived abroad. Participants were assigned to one of four groups. Three of the groups were given the conditions:

1. imagine and write about adapting to a foreign culture;
2. imagine and write about observing a foreign culture;
3. imagine and write about learning a new sport;

The fourth group did not receive any priming task. Those who imagined adapting to a foreign culture produced the most creative drawings. The researchers suggested that living abroad, and particularly adapting to living abroad, requires individuals to utilize different perspectives and to work through ambiguous or unfamiliar situations, which supports creativity.

Conclusions

Overall, there is strong evidence that creativity can be developed in the context of primary and secondary schools and higher education. In the research surveyed here, a particular emphasis was placed on teaching cognitive strategies that support aspects of creativity related to problem-solving and divergent thinking. Specific training in metacognitive awareness may further enhance the creative process. Additionally, research suggests that observational learning can help students develop divergent thinking and produce more creative work products. There is also initial evidence that improvisation and role-playing games can encourage creativity. Lastly, there has been recent interest in applying prejudice-reduction techniques and multiculturalism to creativity research. Violations of our assumptions and stereotypes, as well as the experience of adapting to another culture, appear to support creative thinking, although this may only be true for individuals who do not strongly rely on rules and assumptions in the first place.

These findings are somewhat tempered by methodological limitations in the current research literature. Although there is a vast amount of published literature on creativity, much of it is not well suited to making evidence-based recommendations for teaching. Rather, much of the literature on creativity is strictly theoretical in nature, and existing empirical studies tend to focus on teachers' perceptions of creativity or utilize single-case studies or questionable measures of creativity, such as self-ratings of creative ability. Although some studies incorporated control or comparison groups, many others drew conclusions by examining a single group of students before and after an intervention. With this type of design, we cannot be certain changes in creativity are truly due to the intervention and not some other factor. Likewise, participation in the intervention was voluntary in several studies. This introduces a possible self-selection bias, which can limit our ability to generalize findings to other populations that have less interest in creativity. Future research in teaching creativity should incorporate control groups and random assignment whenever possible, to strengthen the claims made about program effectiveness. Additionally, there is a lack of research on the long-term outcomes of creativity training programs. Of the studies reviewed here, only two assessed outcomes over an extended period. Given the emphasis on creativity as a skill for future success, more evidence of the long-term impact of creativity interventions is needed. In order to support students as they progress into the workforce, interventions during primary, secondary, and higher education need to develop lasting improvements in creativity.

Assessment

The Problem of Assessing Creativity

The first major question regarding the assessment of creativity is whether creativity can actually be measured. In many ways, the idea of creativity as the production of new ideas is at odds with traditional notions of assessment that reward the production of the one, predetermined correct answer. Undergraduate students participating in a focus group while in a studio art class felt that creativity was too subjective to attempt to objectively measure and found a proposed rubric was too prescriptive to capture creativity (Polston, 2016). Others argue that creativity cannot be measured directly but only through self-rating or external recognition (Piffer, 2012). Despite the objections, people have been trying to measure creativity for more than 100 years and have created assessments that are reliable and at least moderately predictive of future creative output.

Types of Assessment

There are three main approaches to assessment of creativity:

1. assessment of divergent thinking;
2. self-ratings;
3. assessment of creative-work products.

ASSESSMENT OF DIVERGENT THINKING

As described above, divergent thinking is the tendency to be able to generate multiple ideas. It is often defined by subskills of fluency, originality, elaboration, and flexibility. One of the most widely used assessments of creativity is the previously mentioned Torrance Tests of Creative Thinking (TTCT; Torrance, Ball, & Safter, 2003). There are two versions of the TTCT: figural, which uses three picture-based exercises, and verbal, which uses six words-based exercises. The picture-based exercises include a picture-construction test in which the examinee is presented with a shape and then asked to draw a picture in which that shape is an integral piece. It also includes picture completion in which an incomplete picture is presented and the examinee is asked to complete it. The verbal version includes a task asking examinees to name as many uses for an object as possible and a product-improvement activity asking examinees to come up with as many ways as possible to improve something (for example, to make a toy more fun to play with).

The figural tasks are scored for fluency, originality, and elaboration, while the verbal tasks are scored for fluency, originality, and flexibility. The authors stopped scoring the figural tasks for flexibility because the scores could not be differentiated from fluency scores (Kim, 2006). There is debate among researchers about whether the four elements can be independently assessed. Some researchers have found the three-dimensional model in the verbal version was confirmed by data (Pásztor, Molnár, & Csapó, 2015), while others have found that tasks with similar format, content, and requirements are more highly related to one another than are tasks that are meant to measure the same element of divergent thinking (Almeida, Prieto, Ferrando, Oliveira, & Ferrándiz, 2008). There is therefore some mixed evidence of validity based on the internal structure of the test.

Another type of validity evidence is whether a test can predict future creativity. There have been longitudinal studies of the TTCT over notably long periods

of time, as long as forty years (Kim, 2006), revealing that there are moderate correlations between the TTCT and future creative production. Notably, these correlations were higher than the correlations between IQ scores and creative production. While it is clear there are many factors needed to predict creative production, divergent-thinking tests appear to be one significant predictor.

There are other divergent-thinking tests that offer similar types of alternate-use activities. Apart from these, another interesting divergent-thinking assessment presents examinees with math problems and asks them to solve them in multiple ways (Leikin, 2009). Individuals' solutions were then categorized as conventional (those taught in the curriculum) versus unconventional and were scored by their originality and the flexibility of thinking identified. Research suggested that this technique was able to differentiate more and less creative students identified by other methods.

SELF-REPORT

Apart from observing people's behavior, creativity has also been measured by asking people to report on their own creativity. There are generally two types of self-report approaches to measuring creativity:

1. reporting on creative works produced (e.g., Carson, Peterson, & Higgins, 2005);
2. self-rating statements related to creative thinking and process (e.g., Runco, Walczyk, Acar, Cowger, Simundson, & Tripp, 2014).

A recent review of six different self-report scales reported that they generally have good reliability, providing consistent scores. However, they are subject to positive skew, and they have only been tested in low-stakes environments (e.g., not used for employment or similar decisions) (Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012). In other words, the assessments are transparent, and it is easy to "fake good" if there is motivation to do so.

ASSESSMENT OF CREATIVE WORKS

The final method of assessing creativity is to actually score creative works that individuals produce. This type of assessment clearly has face validity, as people are asked to make exactly what we are interested in measuring: creative-work products. However, the question remains whether these resulting products can be scored by raters in a way that actually captures creativity. A technique called "consensual assessment" requires experts in the given domain to arrive at consensus about a holistic rating of creativity. Research suggests there is actually substantial agreement among domain experts in ratings, resulting in reliable scores with acceptable evidence for validity based on internal structure (Baer & McKool, 2009). However, most assessment of creative works employs rubrics of some kind. In general, rubrics have been shown to make ratings more reliable (Jonsson & Svingby, 2007), particularly when they are used by trained raters (Clary, Brzuszek, & Fulford, 2011), or include the use of multiple raters (Johnson, Penny, & Gordon, 2000).

The Buck Institute for Education has a freely available rubric for creativity and innovation for problem-based learning for Grades 6–12 that separately rates both process and product. The elements of the process include:

- defining the creative challenge;
- identifying sources of information;
- generating and selecting ideas;
- presenting work.

The final product is then rated on originality, value, and style. For each of these elements there are descriptors for three levels of achievement.

Creativity rubrics are often open to debate about whether all of the elements included are actually related to creativity. For example, review of creativity rubrics for creative writing found many existing rubrics included grammar and punctuation as part of the ratings (Mozaffari, 2013). In addition, there are few studies that look at the validity and reliability of specific rubrics for creativity. One exception was an effort to develop a creative writing rubric. It contained four elements:

1. imagery;
2. characterization;
3. voice;
4. story.

Correlations between two raters using the rubric were high, and the raters' scores also correlated well with an independent expert's ranking of the papers by level of creativity (Mozaffari, 2013).

Automated Scoring

The advent of machine learning and artificial intelligence has greatly increased the interest in the use of automated scoring to standardize the application of scoring rules and to relieve humans of the burden of grading. However, as with skepticism with the ability to assess creativity at all, there is likely to be skepticism that there could be valid non-human scoring of work products. That said, there has been an attempt to conduct an assessment of divergent thinking online (Pásztor et al., 2015). The assessment pulled three task types from two different divergent-thinking assessments, all requiring verbal responses. Theoretically, the originality of a response could be determined based on a norm sample; fluency could be determined from the number of ideas listed; and elaboration could be determined by the number of details provided. The research published by the group so far is preliminary, and, while their system could do these final scoring activities, it still required human scoring to sort responses into categories to determine, for example, if two responses were really the same use for an item or if they should be counted as different uses. That said, the authors expect that with further training the technology should be able to handle this task.

Summary and Recommendations

The research on creativity reviewed in this report leads to a number of important conclusions and implications for practice.

CONCLUSION	IMPLICATION	TIPS FOR CLASSROOM PRACTICE
Creativity is sought after by employers, and high levels of employee creativity are associated with high organizational performance	Educators and employers should create environments that encourage creative expression	Create a classroom environment characterized by learner autonomy, experimentation, low stakes for making mistakes, and opportunities for collaboration and playfulness
Creativity is widely understood as the production of novel and useful ideas	Educators should emphasize both novelty and usefulness as important criteria for interpreting creative contributions	Consider novelty in the context of a developmental continuum, with novices demonstrating ideas that are "new for me"
Creative potential is a complicated function of domain knowledge, cognitive styles, intrinsic task motivation, personality factors, and the environment in which a person works	Educators should be aware of the factors that contribute to creative potential	Think about factors that might be holding learners back from reaching their full creative potential, such as a lack of adequate domain knowledge or motivation to engage in the creative tasks
There is a developmental progression of creativity from novices to eminent creators	Educators should teach and assess with this progression in mind	For younger students, emphasize creative processes and behaviors, whereas for older students, gradually shift emphasis to the value of their creative achievements
Creativity can be taught, particularly creative problem-solving and divergent thinking	Educators should explicitly teach and provide feedback on strategies for divergent or unconventional thinking	Give students opportunities to practice strategies such as problem finding, conceptual combination, and brainstorming
K-12 interventions that employ cooperative learning or collaboration, case-based learning, observational learning or modeling, and pretend play appear to improve divergent thinking	K-12 educators should experiment with these types of techniques in the classroom	Experiment with combining techniques, for example, doing small-group role play or modeling with cooperative learning teams
For higher-education learners, metacognition training, role-playing games and improvisation, and diversification or stereotype reduction training have shown success in enhancing divergent thinking	College instructors should consider how to infuse these kinds of techniques into their teaching	
Divergent thinking tasks are predictive of long-term, real-world creative achievements, and evaluation of creative-work products appears to produce reliable and valid measures of creativity	Educators should consider incorporating both divergent thinking tasks and creative work products to assess creativity and creative potential	Consider looking for evidence of divergent thinking within specific disciplines or domains and scoring work products using a defined creativity rubric with separate dimensions for novelty, usefulness, etc.

Table 3 Conclusions and recommendations.

References

Ai, X. (1999). Creativity and academic achievement: An investigation of gender differences. *Creativity Research Journal*, 12(4), 329–337.

Albert, R. S., & Runco, M. A. (1999). A history of research on creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 16–34). Cambridge: Cambridge University Press.

Alfonso-Benlliure, V., Meléndez, J. C., & García-Ballesteros, M. (2013). Evaluation of a creativity intervention program for preschoolers. *Thinking Skills and Creativity*, 10(1), 112–120.

Almeida, L. S., Prieto, L. P., Ferrando, M., Oliveira, E., & Ferrándiz, C. (2008). Torrance Test of Creative Thinking: The question of its construct validity. *Thinking Skills and Creativity*, 3(1), 53–58.

Altshuller, G., Shulyak, L., Rodman, S., & Fedoseev, U. (1997). 40 principles: *TRIZ keys to innovation*. Worcester, MA: Technical Innovation Center.

Amabile, T. M. (1988). A model of creativity and innovation in organizations. *Research in Organizational Behavior*, 10(1), 123–167.

—— (2012). *Componential theory of creativity*. Boston, MA: Harvard Business School. Retrieved from https://pdfs.semanticscholar.org/6188/5f52d813d518b4ed5b833b4022990211f063.pdf

American Management Association. (2012). *Critical skills survey*. American Management Association. Retrieved from: http://www.amanet.org/uploaded/2012-Critical-Skills-Survey.pdf

Anderson, A., & Yates, G. C. R. (1999). Clay modelling and social modelling: Effects of interactive teaching on young children's creative artmaking. *Educational Psychology*, 19(4), 463–469.

Andrew, J. P., Manget, J., Michael, D. C., Taylor, A., & Zablit, H. (2010). Innovation 2010: *A return to prominence and the emergence of a new world order*. Boston, MA: The Boston Consulting Group. Retrieved from https://www.bcg.com/documents/file42620.pdf

Baer, J. (1998). The case for domain specificity of creativity. *Creativity Research Journal*, 11(2), 173-177.

Baer, J., & McKool, S. S. (2009). Assessing creativity using the consensual assessment technique. In C. S. Schreiner (Ed.), *Handbook of research on assessment technologies, methods, and applications in higher education* (pp. 65-77). Hershey, PA: IGI Global.

Bahar, A. K., & Maker, C. J. (2011). Exploring the relationship between mathematical creativity and mathematical achievement. *Asia-Pacific Journal of Gifted and Talented Education*, 3(1), 33–48.

Bancroft, S., Fawcett, M., & Hay, P. (2008). *Researching children researching the world*: 5 × 5 × 5 = creativity. Stoke-on Trent: Trentham Books Unlimited.

Bandura, A.(1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Beghetto, R. A. (2007). Does creativity have a place in classroom discussions? Prospective teachers' response preferences. *Thinking Skills and Creativity*, 2(1), 1–9.

Besançon, M. (2006). Development of creativity: The influence of school environment and cognitive factors. Unpublished doctoral dissertation, Paris Descartes University.

Borradaile, L. (2006). *Forest School Scotland: An evaluation. Report to Forestry Commission Scotland and Forest Education Initiative Scotland.* Retrieved from http://www.forestry.gov.uk/pdf/forestschoolfinalreport.pdf/$file/forestschoolfinalreport.pdf

Braund, M., & Campbell, R. (2010). Learning to teach about ideas and evidence in science: The student teacher as change agent. *Research in Science Education*, 40(2), 203–222.

Burgess, L., & Addison, N. (2007). Conditions for learning: Partnerships for engaging secondary pupils with contemporary art. *JADE*, 26(2), 185–198.

Burnard, P., Craft, A., & Cremin, T. (2006). Documenting 'possibility thinking': A journey of collaborative enquiry. *International Journal of Early Years Education*, 14(3), 243–262.

Carson, S. H., Peterson, J. B., & Higgins, D. M. (2005). Reliability, validity, and factor structure of the creative achievement questionnaire. *Creativity Research Journal*, 17(1), 37–50.

Casner-Lotto, J., & Barrington, L. (2006). *Are they really ready to work? Employers' perspectives on the basic knowledge and applied skills of new entrants to the 21st century US workforce.* Washington, DC: Partnership for 21st Century Skills.

Chang, Y., Chien, Y., Yu, K., Chu, Y., Chen, M. Y. (2016). Effect of TRIZ on the creativity of engineering students. *Thinking Skills and Creativity*, 19, 112–122.

Cheung, C., Roskams, T., & Fisher, D. (2006). Enhancement of creativity through a one-semester course in university. *Journal of Creative Behavior,* 40(1), 1–25.

Chung, T. S. (2013). Table-top role playing game and creativity. *Thinking Skills and Creativity,* 8, 56–71.

Clary, R. M., Brzuszek, R. F., & Fulford, C. T. (2011). Measuring creativity: A case study probing rubric effectiveness for evaluation of project-based learning solutions. *Creative Education*, 2(4), 333-340.

Cochrane, P. & Cockett, M. (2007). *Building a creative school: A dynamic approach to school development.* Stoke-on Trent: Trentham Books Unlimited.

Cremin, T., Burnard, P., & Craft, A. (2006). Pedagogy and possibility thinking in the early years. *Thinking Skills and Creativity,* 1(2), 108–119.

Csikszentmihalyi, M. (2014). *The systems model of creativity.* Dordrecht: Springer.

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education: A systematic literature review. *Thinking Skills and Creativity,* 8, 80–91.

Dillon, P., Craft, A., Best, P., with Rigby, A., & Simms, K. (2007). *Turning peases west inside out: Flexible educational environments for developing possibilities and pedagogies.* Durham: Creative Partnerships.

Dyson, A. B., Chang, Y., Chen, H., Hsiung, H., Tseng, C., & Chang, J. (2016). The effect of tabletop role-playing games on the creative potential and emotional creativity of Taiwanese college students. *Thinking Skills and Creativity,* 19, 88–96.

Feldhusen, J. J., Speedie, S. M., & Treffinger, D. J. (1971). The Purdue creative thinking program: Research and evaluation. *National Society for Performance and Instruction Journal,* 10(3), 5–9.

Ferrari, A., Cachia, R., & Punie, Y. (2009). *Innovation and creativity in education and training in the EU member states: Fostering creative learning and supporting innovative teaching.* Seville: European Commission Joint Research Centre.

Gadd, K. (2011). *TRIZ for engineers*. Chichester: John Wiley Sons.

Gajda, A., Karwowski, M., & Beghetto, R. A. (2016). Creativity and academic achievement: A meta-analysis. *Journal of Educational Psychology*, 109(2): 269–299.

Garaigordobil, M. (2006). Intervention in creativity with children aged 10 and 11 years: Impact of a play program on verbal and graphic-figural creativity. *Creativity Research Journal,* 18(3), 329–345.

Gilson, L. L., Mathieu, J. E., Shalley, C. E., & Ruddy, T. M. (2005). Creativity and standardization: Complementary or conflicting drivers of team effectiveness? *Academy of Management Journal,* 48(3), 521–531.

Gkolia, C., Brundett, M., & Switzer, J. (2009). An education action zone at work: Primary teacher perceptions of the efficacy of a creative learning and collaborative leadership project. Education 3–13, 37(2), 131–144.

Gocłowska, M. A., Baas, M., Crisp, R. J., & De Dreu, C. K. W. (2014). Whether social schema violations help or hurt creativity depends on need for structure. *Personality and Social Psychology Bulletin*, 40(8), 959–971.

Gocłowska, M. A., & Crisp, R. J. (2013). On counter-stereotypes and creative cognition: When interventions for reducing prejudice can boost divergent thinking. *Thinking Skills and Creativity*, 8, 72–79.

Griffin, P., McGaw, B., & Care, E. (Eds.) (2012). *Assessment and teaching of 21st century skills*. New York, NY: Springer.

Groenendijk, T., Janssen, T., Rijlaarsdam, G., & van den Bergh, H. (2013). Learning to be creative: The effects of observational learning on students' design products and processes. *Learning and Instruction*, 28, 35–47.

Guilford, J. P. (1950). Creativity. *American Psychologist*, 5(9): 444–454.

—— (1967). *The nature of human intelligence.* New York, NY: McGraw-Hill.

Han, K. S., & Marvin, C. (2002). Multiple creativities? Investigating domain-specificity of creativity in young children. *Gifted Child Quarterly*, 46(2), 98-109.

Hargrove, R. A. (2012) Assessing the long-term impact of a metacognitive approach to creative skills development. *International Journal of Technology and Design Education*, 23(3), 489–517.

Hu, W., Wu, B., Jia, X., Yi, X., Duan, C., Meyer, W., & Kaufman, J. C. (2013). Increasing students' scientific creativity: The "Learn to Think" intervention program. *Journal of Creative Behavior,* 47(1), 3–21.

Hui, A. N. N., Chow, B. W. Y., Chan, A. Y. T., Chui, B. H. T., & Sam, C. T. (2015). Creativity in Hong Kong classrooms: Transition from a seriously formal pedagogy to informally playful learning. *Education* 3–13, 43(4), 393–403.

IBM Institute for Business Value (2016). Redefining competition: Insights from the Global C-suite study—The CEO perspective. Retrieved from http://www-01.ibm.com/common/ssi/cgi-bin/ssialias?subtype=XB&infotype=PM&htmlfid=GBE03695USEN&attachment=GBE03695USEN.PDF

Jeffrey, B. (2006). Creative teaching and learning: Towards a common discourse and practice. *Cambridge Journal of Education*, 36(3), 399–414.

Johnson, R. L., Penny, J., & Gordon, B. (2000). The relation between score resolution methods and interrater reliability: An empirical study of an analytic scoring rubric. *Applied Measurement in Education*, 13(2), 121–138.

Jonsson, A., & Svingby, G. (2007). The use of scoring rubrics: Reliability, validity and educational consequences. *Educational Research Review*, 2(2), 130–144.

Karakelle, S. (2009). Enhancing fluent and flexible thinking through the creative drama process. *Thinking Skills and Creativity*, 4(2), 124–129.

Karwowski, M., & Soszynski, M. (2008). How to develop creative imagination? Assumptions, aims and effectiveness of role play training in creativity (RPTC). *Thinking Skills and Creativity*, 3(2), 163–171.

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.

Kendall, L., Morrison, J., Yeshanew, T., & Sharp, C. (2008). The longer-term impact of *Creative Partnerships on the attainment of young people: Results from 2005 and 2006*. Slough: NFER.

Kendall, S., Muirfield, J., White, R., & Wilkin, A. (2007). *Engaging Places research summary.* Slough: National Foundation for Educational Research.

Kim, K. H. (2006). Can we trust creativity tests? A review of the Torrance Tests of Creative Thinking (TTCT). *Creativity Research Journal,* 18(1), 3–14.

Kozbelt, A., Beghetto, R. A., & Runco, M. A. (2010). Theories of creativity. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge handbook of creativity* (pp. 20–47). Cambridge: Cambridge University Press.

Kurtzberg, R. L., & Reale, A. (1999). Using Torrance's problem identification techniques to increase fluency and flexibility in the classroom. *Journal of Creative Behavior,* 33(3), 202–207.

Leikin, R. (2009). Exploring mathematical creativity using multiple solution tasks. In R. Leikin, A. Berman, & B. Koichu (Eds.), *Creativity in mathematics and the education of gifted students* (pp. 129–145). Rotterdam: Sense Publishers.

Lopez, E. C., Esquivel, G. B., & Houtz, J. C. (1993). The creative skills of culturally and linguistically gifted and diverse students. *Creativity Research Journal,* 6(4), 401–412.

Ma, H. (2006). A synthetic analysis of the effectiveness of single components and packages in creativity training programs. *Creativity Research Journal*, 18(4), 435–446.

Maddux, W. W., & Galinsky, A. D. (2009). Cultural borders and mental barriers: The relationship between living abroad and creativity. *Journal of Personality and Social Psychology,* 96(5), 1047–1061.

Maker, C. J., Jo, S., & Muammar, O. M. (2008). Development of creativity: The influence of varying levels of implementation of the DISCOVER curriculum model, a non-traditional pedagogical approach. *Learning and Individual Differences*, 18(4), 402–417.

Menter, I. (2010). T*eachers: Formation, training and identity—A literature review*. Newcastle: Creativity, Culture and Education.

Michalko, M. (2006). *Thinkertoys*. Berkeley, CA: Ten Speed Press.

Mozaffari, H. (2013). An analytical rubric for assessing creativity in creative writing. *Theory and Practice in Language Studies*, 3(12), 2214-2219.

Osborn, A. (1963). *Applied imagination*. New York, NY: Scribner's.

Parnes, S. J. (1966). *Instructor manual for institutes and courses in creative problem solving.* Buffalo, NY: Creative Education Foundation.

Pásztor, A., Molnár, G., & Csapó, B. (2015). Technology-based assessment of creativity in educational context: The case of divergent thinking and its relation to mathematical achievement. *Thinking Skills and Creativity*, 18, 32–42.

Pellegrino, J. W., & Hilton, M. L. (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century.* Washington, DC: National Academy of Sciences.

Piffer, D. (2012). Can creativity be measured? An attempt to clarify the notion of creativity and general directions for future research. *Thinking Skills and Creativity,* 7(3), 258–264.

Pitso, T. (2013). The creativity model for fostering greater synergy between engineering classroom and industrial activities for advancement of students' creativity and innovation. *International Journal of Engineering Education,* 29(5), 1–8.

Plucker, J. A., Beghetto, R. A., & Dow, G. T. (2004). Why isn't creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research. *Educational Psychologist,* 39(2), 83–96.

Polston, K. (2016). Students' perceptions and attitudes towards rubric assessment of creativity. *International Textile and Apparel Association Annual Conference Proceedings.* Retrieved from http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1527&context=itaa_proceedings

Renzulli, J. S. (1973). *New directions in creativity: Mark 1.* New York, NY: Harper.

Ritter, S. M., Damian, R. I., Simonton, D. K., Van Baaren, R. B., Strick, M., Derks, J., & Dijksterhuis, A. (2012). Diversifying experiences enhance cognitive flexibility. J*ournal of Experimental Social Psychology*, 48(4), 961–964.

Robbins, T. L., & Kegley, K. (2010). Playing with Tinkertoys to build creative abilities through online instruction. *Thinking Skills and Creativity*, 5(1), 40–48.

Runco, M. A. (1996). Personal creativity: Definition and developmental issues. *New Directions for Child and Adolescent Development*, 72, 3–30.

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal*, 24(1), 66–75.

Runco, M. A., Walczyk, J. J., Acar, S., Cowger, E. L., Simundson, M., & Tripp, S. (2014). The incremental validity of a short form of the Ideational Behavior Scale and usefulness of distractor, contraindicative, and lie scales. *Journal of Creative Behavior*, 48(3), 185–197.

Rutland, M., & Barlex, D. (2008). Perspectives on pupil creativity in design and technology in the lower secondary curriculum in England. *International Journal of Technology and Design Education*, 18(2), 139–165.

Sapp, D. D. (1995). Creative problem-solving in art: A model for idea inception and image development. *Journal of Creative Behaviour*, 29(3), 173–185.

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.

Scott, G., Leritz, L. E., & Mumford, M. D. (2004a). Types of creativity training: Approaches and their effectiveness. *Creativity Research Journal,* 16(4), 361–388.

—— (2004b). The effectiveness of creativity training: A quantitative review. Journal of *Creative Behavior*, 38(3), 149–179.

Sharp, C., Pye, D., Blackmore, J., Brown, E., Eames, A., Easton, C., Filmer-Sankey, C., Tarbary, A., Whitby, K., Wilson, R., & Benton, T. (2006). *National evaluation of creative partnerships: Final report*. London: Creative Partnerships.

Silvia, P. J., Wigert, B., Reiter-Palmon, R., & Kaufman, J. C. (2012). Assessing creativity with self-report scales: A review and empirical evaluation. *Psychology of Aesthetics, Creativity, and the Arts*, 6(1), 19-34.

Simonton, D. K. (1997). Creative productivity: A predictive and explanatory model of career trajectories and landmarks. *Psychological Review,* 104(1), 66-89.

Sternberg, R. J. (2006). The nature of creativity. *Creativity Research Journal,* 18(1), 87–98.

Sternberg, R. J., & Lubart, T. I. (1992). Buy low and sell high: An investment approach to creativity. *Current Directions in Psychological Science*, 1(1), 1–5.

—— (1999). The concept of creativity: Prospects and paradigms. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 1–15). Cambridge: Cambridge University Press.

Sternberg, R. J., Kaufman, J. C., & Pretz, J. E. (2001). The propulsion model of creative contributions applied to the arts and letters. *Journal of Creative Behavior*, 35(2), 75–101.

Torrance, E. P. (1978). Giftedness in solving future problems. *Journal of Creative Behavior*, 12(2), 75–86.

Torrance, E. P., Ball, O. E., & Safter, H. T. (2003). *Torrance tests of creative thinking*. Bensonville, IL: Scholastic Testing Service.

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times.* San Francisco, CA: Jossey-Bass.

Westby, E. L., & Dawson, V. L. (1995). Creativity: Asset or burden in the classroom? *Creativity Research Journal*, 8(1), 1–10.

Wood, R., & Ashfield, J. (2008). The use of the interactive whiteboard for creative teaching and learning in literacy and mathematics: A case study. B*ritish Journal of Educational Technology*, 39(1), 84–96.

World Economic Forum. (2016). *The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution*. Geneva: World Economic Forum. Retrieved from http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

Yi, X., Plucker, J. A., & Guo, J. (2015). Modeling influences on divergent thinking and artistic creativity. *Thinking Skills and Creativity,* 16, 62–88.

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