Chapter 9
Collaborative Creativity and Innovation in Education

Jonali Baruah and Paul B. Paulus

Abstract As organizations are becoming increasingly dependent on collaborative teamwork there has been a major shift in focus from individual to team based innovation. Value is increasing in promoting team level creative competence in students. Hence, this chapter examines research on creativity with a special focus on collaborative creativity and its application in the context of education. We discuss the theoretical basis for collaborative creativity, different techniques for generating ideas in groups, the process of selecting the best ideas, and the role of culture and diversity in collaborative creativity. We then review the literature on collaborative creativity in various education disciplines. Finally, we make research- based recommendations on ways to promote as well as enhance collaborative creativity and innovation in educational settings.

9.1 Introduction

Corporations must be creative in order to survive. Creativity is required in every aspect of business from designing a product or service to advertising and marketing and to making final implementations. Hence, there has been an increasing emphasis on the development of creative competence in educational institutions as a common curricular goal to help prepare students for an uncertain future (Beghetto, 2010).

Collaborative teamwork and team-based creativity now dominate most US companies in public as well as private sectors to help accomplish organizational goals and activities (Anderson, Potočnik, & Zhou, 2014; Sawyer, 2017). In response, the goal of this chapter is to examine research on creativity with special focus on

J. Baruah (✉)
Tarleton State University, Fort Worth, TX, USA
e-mail: baruah@tarleton.edu

P. B. Paulus
University of Texas at Arlington, Arlington, TX, USA
e-mail: paulus@uta.edu

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collaborative creativity and its application in the context of education. We begin with theoretical underpinnings and some key issues in the area of creativity and innovation. We then discuss various methods and processes of creativity, as well as social and cognitive factors that play roles in this process with a special focus on educational context. After that, we examine the literature on creative education in different disciplines. Finally, we conclude with recommendations and implications for both educators and researchers.

Creativity and innovation are often used to represent different aspects of the innovation process. The essence of innovation is the generation of ideas (creativity), selection of ideas that involve thorough evaluation, and application or implementation of the final idea or product. Thus, creativity is often considered the first stage of the innovation process.

9.1.1 Idea Generation

Brainstorming is a most widely used and potentially useful technique for generating creative ideas (Osborn, 1963). Since it is simple to use and is the most researched approach to collaborative creativity sessions, we examine it in detail. Much of the literature on brainstorming research reveals a suboptimal performance at group level compared to individual level brainstorming (e.g., Diehl & Stroebe, 1987). This shows that groups generate fewer ideas than the same number of individuals working in isolation (nominal groups). Factors associated with this outcome are discussed after we briefly discuss theoretical underpinnings.

9.1.2 Theoretical Underpinnings

Theoretically speaking, a team should perform better than the same number of individuals performing in isolation. The diverse skills and expertise brought in by team members can complement each other in attaining specific goals (Saavedra, Earley, & Van Dyne, 1993). For example, developing a software application may require a team of interdependent individuals with varied expertise. Here is one such scenario: a software programmer focusing on developing the software, a business analyst gathering requirements of the product, a quality control analyst checking the effectiveness of the product, and a user interface designer designing the look and feel of a product. In addition, the interaction process among different team members can generate cognitive stimulation, allowing groups to develop creative solutions that would not otherwise occur (Baruah & Paulus, 2009).

Several models of group creativity (i.e., Nijstad & Stroebe, 2006; Paulus & Brown, 2007) propose that sharing and building on each others' ideas in a group setting should produce cognitive stimulation. Paulus and Brown's (2007) cognitive-social-motivational model of group creativity suggests that group creativity combines cognitive processing in which members actively engage in search of ideas and social exchange. Group members build on each other's ideas to generate more and better ideas. Thus, one can expect a superior performance in a group through a high level of cognitive processing along with a successful exchange in collaborative environments after controlling for factors inhibiting performance within a group context. Similarly, the Search for Ideas in Associative Memory (SIAM) model by Nijstad and Stroebe (2006) posits the importance of spreading activation of ideas through search cues. Cues in human memory strongly associated with the search cue are the ones that will be activated. In a group setting, the ideas of others that are attended to result in stimulation of further ideas. However, SIAM also adds that in a group setting where members wait for their turns to speak or respond, delays occur between the generation and articulation of ideas. This delay may result in forgetting. However, as groups show greater persistence in generating ideas than individuals, teams can compensate for the productivity loss if members are given additional time (Nijstad, Stroebe, & Lodewijkx, 2003).

9.2 How to Generate More and Better Ideas

The level of performance in the context of collaborative exchange is often evaluated in conjunction with the modality of brainstorming used. Although the traditional method of collaborative exchange in groups is verbal brainstorming, several other methods have been developed. We next discuss the impact of various methods of brainstorming to optimal performance and key issues associated with each one.

9.2.1 Verbal Brainstorming

Hindu teachers in India used verbal or face-to-face brainstorming for over 400 years to solve problems or share ideas with their pupils (Osborn, 1963). During such a session of *Prai* (meaning, being outside yourself)—*Barshana* (pouring) no discussion or criticism took place. Osborn was the first proponent of using group brainstorming as a way to increase the creativity of organizations. The original concept was to assemble a group and allow them come up with ideas using four rules: do not criticize, quantity is wanted, combine and improve suggested ideas, and express all ideas that come to mind, no matter how wild. Researchers often use these rules expecting that the cognitive stimulation from hearing others' ideas will trigger new ideas and that the "piggybacking" of ideas will lead to more and better quality ideas. If one person's ideas should stimulate ideas for another, then a larger pool of ideas can be generated by increasing group size. However, contrary to this expectation, studies of verbal brainstorming groups have found that such groups experience a production loss relative to nominal groups as group size increases (Bouchard & Hare, 1970).

A number of key factors appear to be responsible for the productivity loss in verbal brainstorming groups. One such factor is production blocking or collaborative inhibition, that is, the inability to express ideas as they come to mind (Diehl & Stroebe, 1987; Nijstad & Stroebe, 2006). Other factors that can play a role in productivity loss are evaluation apprehension (individuals' concern about others' perception of their ideas) (Diehl & Stroebe), in addition to social loafing (letting others do the work in groups) and downward comparison (converging toward the performance level of low performers in a group) (Paulus & Dzindolet, 1993).

Since the face-to-face modality is not particularly conducive to the idea exchange process in terms of generating many novel ideas, researchers have examined other methods. These include exchanging ideas on slips of paper (brainwriting) and via computers (electronic brainstorming). We elaborate in the next section.

9.2.2 Brainwriting and Its Variations

While the data on verbal brainstorming technique are extensive, far less data are available on these techniques where communication occurs as written words or sketches. In the classic brainwriting technique, face-to-face group participants silently write down their ideas on paper and place the slips in the center of the table. Each member is free to pull out one or more of these ideas to stimulate new ideas. Some field studies (e.g., VanGundy, 1995) and experimental ones (e.g., Paulus & Yang, 2000) have found that brainwriting groups produce more ideas than verbal brainstorming groups. Heslin (2009) has identified some of the potential boundary conditions under which brainwriting can be an effective alternative to other well-known brainstorming paradigms: when time is available, when one is looking for high quality ideas, and when group members have unique expertise.

Several studies in the field of design and engineering have demonstrated the use of brainwriting, sketching, and 6-3-5 as methods in the idea generation process. Linsey and Becker (2011) had participants begin by silently sketching their ideas on large sheets of paper, including brief annotations (brainsketching). This technique allows for a visual means of expression and so it is considered suited for design engineers. The researchers reported that the use of words and sketches together resulted in a higher quantity of ideas among face-to-face groups compared with nominal groups. Earlier, Van der Lugt (2002) found the brainsketching approach to be a better technique for building on previously generated ideas than did brainstorming among a group of product development students. More recently, Leahy and Mannix-McNamara (2016) subjected a group of Irish high school students to brainstorming on a given problem in small groups of four to seven in phase 1 (control) and brainsketching in phase 2 (experimental). Their data analysis indicated that brainsketching increased the students' intrinsic motivation in the design-based problem solving activity. This finding suggests that use of a strategic brainsketching approach for creative design based activities in education is likely conducive to creative idea generation.

A few other variations of this method are 6-3-5 (Shah, Vargas-Hernandez, Summers, & Kulkarni, 2001) and C-sketch (Shah, 1998). For 6-3-5, a group of six participants is seated around a table and each silently describes three ideas on a large sheet of paper. The ideas are passed to another participant. This exchange goes on for five rounds. For the original 6-3-5 method, ideas are described using only words. In contrast, the C-Sketch method permits only sketches. Researchers have found that the C-Sketch has an advantage over 6-3-5 in that sketches are typically ambiguous and can lead to misinterpretation of others' sketch. These misinterpretations give rise to unlikely ideas, which can be tied to the existing problem to subsequently create novel ideas (Shah et al., 2001).

Vidal, Mulet, and Gómez-Senent (2004) compared verbal brainstorming with brainsketching and the objectual (showing rudimentary objects) technique. In the brainsketching paradigm, participants silently drew sketches of their ideas on pieces of paper whereas in objectual paradigm, participants silently presented objects, not sketches, to their teammates. The researchers found that the verbal brainstorming resulted in the maximum number of ideas generated, but that the participants had not gone into the depth of the issue in this paradigm, hence the ideas are not highly developed. However, both the brainsketching and objectual method helped with exploring deeper into the solutions.

Although brainwriting has been found to be effective, it has a disadvantage. In a brainwriting, paradigm individuals need to make an effort to pick up and read ideas written by others. Hence, there is a likelihood of paying more attention to one's own ideas. Michinov (2012) indirectly suggested that due to a lack of attention to shared ideas more irrelevant ideas are generated in brainwriting than electronic brainstorming (EBS). However, contrary to Michinov's findings, Litcanua, Prosteana, Orosa and Mnerieb (2015) reported that brainwriting minimizes the effects of digression from a focal topic, status differentials and pressure to conform to group norms.

In sum, it appears that brainwriting is superior to traditional verbal brainstorming and that it is an effective approach to minimizing production loss and maximizing performance in some disciplines. Design engineering is one such discipline where engineers rely heavily on objects and sketches. However, more research is needed on the different variations of brainwriting and brainsketching to determine their relative effectiveness for different types of creative activities.

9.2.3 Electronic Brainstorming (EBS)

With EBS, participants interact using computers. Rather than speaking their ideas or writing them on paper, they type them into special computer software (e.g., a group decision support system) that collects the ideas and shares them with the group. There is also an option for keeping the brainstormers anonymous. If anonymity is maintained, production loss due to evaluation apprehension is minimized (Dennis & Valacich, 1993), but social loafing may worsen (Karau & Williams, 1993).

In terms of process gains, such groups have shown increased creativity over time (Baruah & Paulus, 2016) and increased stimulation due to the production of large pool of ideas (Paulus, Kohn, Arditti, & Korde, 2013). Several studies (cf., De Rosa, Smith, & Hantula, 2007) have found that the performance of EBS rises when the group size reaches 9 or higher. However, Paulus et al. (2013) reported that with this group size the average increase in productivity only ranged from 1 to 2.5 ideas per person. One reason for this limited benefit could be that electronic brainstormers pay more attention to non-task related communications and thus generate many irrelevant ideas (Ziegler, Diehl, & Zijlstra, 2000). Hence, an additional instruction to pay attention to the task and build on members' ideas after participants have generated a significant number of ideas may be helpful in the EBS paradigm (Paulus et al., 2013).

9.2.4 Asynchronous Brainstorming

In response to the changing style of communications from written to virtual in organizations and from face-to-face to online modalities in teaching and learning, new areas of research have evolved. The asynchronous brainstorming paradigm refers to the communications where group members engage in discussions or share messages through digital media and do not face traditional time constraints as they can post messages when convenient. All ideas, submitted individually to a common forum, are available to all group members. This modality has the possibility of reducing cognitive interference since group members' ongoing train of thought is not disrupted by others' ideas.

In a workplace setting, an asynchronous brainwriting paradigm resulted in higher productivity compared to a group brainwriting paradigm (Paulus, Korde, Dickson, Carmeli, & Cohen-Meitar, 2015). In an educational setting, Abrams (2003) found that the asynchronous paradigm resulted in the expression of fewer ideas and words, less lexical richness and diversity in language used compared to the synchronous paradigm. However, there was a reduction in motivation in that members had to wait for others' responses and for extended periods (i.e., several days). In another study, Abrams (2005) found that asynchronous group discussion among graduate students resulted in enhanced critical thinking. They were able to provide well-thought-out responses to their peers not evident in face-to-face paradigm of group discussion.

9.2.5 Hybrid Brainstorming

Although much focus has been on comparing the performance of groups with nominal groups, in reality most creativity involves both individual and group activity. Combining individual and group brainstorming in a single paradigm, or hybrid brainstorming, may be an effective approach (Korde & Paulus, 2017). Findings related to the sequence of individual and group creativity are mixed. In one study, the performance of verbal brainstorming was elevated when participants engaged in a solitary session followed by group brainstorming (Baruah & Paulus, 2008). This sequence makes sense. At the beginning of a brainstorming session, one may not need stimulation from group members to come up with ideas that are readily accessible in memory (Paulus & Brown, 2007). Once someone finds it more difficult to think of additional ideas alone, exposure to ideas in a group setting provides cues for tapping additional knowledge or memory stores. Furthermore, the alone-to-group brainstorming sequence may also be beneficial since the rapid pace of ideation in alone condition may be carried over to the group condition (Baruah & Paulus, 2008).

Other studies have identified a benefit of the group-to-alone sequence (e.g., Korde & Paulus, 2017; Paulus, & Yang, 2000). Korde and Paulus (2017) found that group brainwriting followed by an individual brainwriting session resulted in enhanced performance compared to a group only or individual only session. The enhanced performance was observed in the alone sessions after the group sessions, consistent with Paulus and Yang's (2000) findings and the cognitive model of brainstorming (Paulus & Brown, 2007). Consistent with these outcomes, Girotra, Terwiesch, and Ulrich (2010) reported that participants using the hybrid process generated three times more ideas than those in the face-to-face groups only. Thus, considerable evidence suggests that a mixture of individual and group brainstorming may be optimal.

9.3 Recommendations for Brainstorming

We have focused our review thus far on the brainstorming literature as this is the most extensive research literature on collaborative creativity and it has a strong theoretical base. Most of the studies were completed with college populations in short-term settings. We have found no systematic studies on brainstorming in younger populations or as a means of enhancing the educational process. This is in large part due to the fact of limitations on research on younger populations and the fact that the focus in education is mostly on learning not creativity, let alone collaborative creativity. We return to this larger issue in the conclusion section. However we will briefly summarize some of the basic findings and practical suggestions that would be relevant to the application of brainstorming in an educational environment for student groups, groups of educators, administrators, and policymakers.

1. The method of sharing ideas has a strong impact on groups' creative output. Sharing ideas by sharing ideas in writing or electronically increases the quantity of ideas and the extent to which all group members can contribute.
2. Verbal brainstorming is probably the most popular method brainstorming in real-world settings and participants tend to enjoy it more than the other versions of brainstorming such as electronic brainstorming. However, unless participants also write down their ideas or record these for transcription, many shared ideas may be lost.

3. Short training sessions incorporating aspects of accountability, enhanced application of diverse ideas and detailed feedback can increase the effectiveness of group brainstorming (Baruah & Paulus, 2008).
4. Alternating individual and group brainstorming seems to be most optimal process for generating the most ideas in a group context (Korde & Paulus, 2017).
5. For verbal interaction, it is best to keep groups small. Pairs can be optimal for a broad scope problem if a diversity of perspectives is not needed. Otherwise, a group no larger than the diverse perspectives required is recommended.
6. Although electronic idea exchange processes could be used for school settings, these present a challenge in terms of coordination and collecting the ideas. Brainwriting in groups may be a useful alternative to ensure equal participation, effective exchange of ideas, and easy accumulation of the shared ideas for later evaluation. More research is needed on the utility of different forms of brainwriting or brainsketching for a variety of creativity tasks (e.g., design, arts, open-ended idea sessions).

9.4 Idea Selection

Although much of the creativity literature has focused on the idea generation phase of innovation, innovation is incomplete unless suitable ideas are designated for implementation. The selection of ideas is a critical part of innovation but this area has received relatively little research attention (see Rietzschel, Nijstad, & Stroebe, in press). A few experimental studies in this area reveal that the generation of good ideas in a brainstorming phase does not guarantee selection of equally good or better ideas in an idea selection phase (Rietzschel, Nijstad, & Stroebe, 2006). Additionally, it has been found that the average quality of selected ideas was not superior to the average quality of generated ideas (Rietzschel et al., 2006). Neither solitary nor group brainstormers select the best ideas, although solitary brainstormers generate more original ideas than groups (Putman & Paulus, 2009).

In practice, there is often a strong tendency for people to underestimate the originality of truly novel ideas (Licuanan, Dailey, & Mumford, 2007) and instead to default to selecting feasible or practical ideas (Putman & Paulus, 2009; Rietzschel, Nijstad, & Stroebe 2010) over the original or creative ones. Consequently, novel ideas may not be incorporated into a final product or innovation. People can fail to identify original or truly novel ideas because they have difficulty evaluating atypical or inaccessible ideas (Licuanan et al., 2007) or because they are by nature risk-averse. Since the selection of a radical idea carries uncertainties, brainstormers are often reluctant to choose these options over feasible ideas (Baer, 2012).

9.5 How to Select the Best Ideas

9.5.1 Facilitation

Facilitation at the stage of idea selection can be helpful in the selection of the best ideas. Rietzschel et al. (2010) reported that the participant's tendency to rely on feasibility as a dominant selection criterion could be minimized by giving specific creativity instructions during the idea selection phase. They also reported that participants found it difficult to take both originality and feasibility into account because they perceived the two to be incompatible. Hence providing specific instruction geared towards focusing on a specific criterion of creativity may be beneficial. Alternatively, a process in which the participants first select the creative ideas and then refine them to make them better might also improve the overall quality of ideas.

9.5.2 Refinement of Selected Ideas

Few studies in creativity literature have examined idea refinement. This involves strong attentional demands and controlled processing as brainstormers go through deeper processing and evaluation of their ideas to make them more suitable for meeting requirements. Since it is difficult for a group's best ideas to survive from the idea generation into a final implementation stage, allowing a separate stage of refinement will help the brainstormers to create better solutions to the problem. Frederiksen and Knudsen (2017) emphasized the importance of idea revision before the final implementation to minimize the likelihood of premature rejection of ideas. Similarly, Rietzschel et al. (in press) argued that revision of ideas to make them suitable for final implementation could reduce the tension between the feasibility and originality of ideas. Thus, by giving specific instructions to direct participants' attention to refine each of the selected ideas during a separate idea refinement stage, the participants should be able to generate ideas that are more creative. Additionally, as the process of refinement involves deeper processing, it might lead to greater elaboration of each idea. Research shows that greater elaboration is associated with enhanced originality of ideas (e.g., Rietzschel et al.).

9.6 Recommendations for Idea Section

Although generating many novel ideas is often a desirable goal, in most contexts such as education only a few ideas can be implemented, requiring a selection process. The research we have discussed suggests that selection of the "best" ideas can be a challenge for both individuals and groups. Combined with our experience, the literature leads us to make these suggestions:

1. To enhance the selection of novel ideas in groups, groups should be instructed to select ideas with novelty in mind.
2. Although solitary brainstorming is often the most effective strategy for generating a host of ideas, individuals' ideas still need to be evaluated by some collective to determine their novelty and potential utility.
3. To date, there have been no studies on training groups to become more effective in selecting the best ideas from a pool of generated ideas. It would seem that enhanced experience and efficacy (ability to produce the desired result) with the collaborative creative process might be associated with increased effectiveness in the selection process. In particular, it is important to overcome the initial bias to feasibility.
4. Evaluation of ideas is probably best done in small groups after a brainstorming session. With verbal brainstorming, it may be a difficult process since members have to rely on their memory for the shared ideas. In brainwriting, members can pass around the ideas and mark those they think are worth further discussion. Regarding electronic exchanges, a printout of the shared ideas could be provided for evaluation purposes.
5. If brainstorming sessions are fairly long, having periodic evaluation sessions in between brainstorming sessions may be optimal for avoiding an overload of ideas. This way, groups end up with subsets of favored ideas to evaluate at the end.
6. Once a subset of ideas is selected, these may require further refinement and development. For example, highly novel ideas will need to be modified to make them more feasible or applicable.

9.7 Diversity and Collaborative Creativity

A major benefit of group interaction in problem solving situations is exposure to different perspectives on a given problem. Groups that have members with different experiences and expertise relevant to a problem should be able to think of more creative and useful ideas in part because of their diverse knowledge and mutual stimulation of ideas (Paulus & van der Zee, 2015). Alternatively, variation in expertise or background may result in conceptual or intellectual gaps, which may hinder group performance or creativity (Cronin & Weingart, 2007). Diversity in groups can be based on variations in expertise (functional or informational diversity) or personal characteristics such as gender, race, culture, and personality (demographic diversity).

Although groups should benefit from intellectual or experiential diversity, thus far the literature has been mixed in terms of the support expressed for this expectation. Research shows that functional informational diversity in terms of heterogeneity in knowledge, expertise, or experiences in teams can enhance creative performance (Hülsheger, Anderson, & Salgado, 2009; Jackson, May, & Whitney, 1995). However, when multiple perspectives are at odds, high diversity may make it harder to resolve differences among perspectives (Olson, Walker, & Ruekert, 1995). Thus, it is not surprising that some researchers have found no effect of functional diversity on innovation (e.g., Sethi, Smith, & Park, 2001).

Science and engineering teams are becoming multidisciplinary. As a result, such teams are encouraged to collaborate and thereby increase the likelihood of generating breakthrough solutions to the problems (Dunbar, 1997). Jackson et al. (1995) reported that task-oriented diversity attributes, such as education, function, and tenure are associated with higher elaboration (deeper processing) of ideas through exchange of information among group members. Bell, Villado, Lukasik, Belau, and Briggs (2011) found that educational background diversity was strongly correlated with creativity and that it was most beneficial for design and product development teams.

Benefits of demographic diversity (e.g., gender, age, ethnicity, and race) in creativity have been more limited. Possibly, some initial potential discomfort in groups that are demographically diverse may restrict members' creative potential. However, once familiarity develops with each other and interpersonal trust develops, benefits can occur. For example, Watson, Kumar, and Michealson (1993) compared culturally diverse groups with homogenous groups, and reported that in the beginning the homogeneous groups exhibited enhanced creative performance. However, over time, the diverse groups scored higher in problem identification, quality of solutions, and overall performance. Moreover, if group members have a positive attitude to diversity in the group they are more likely to demonstrate a creative benefit such as increase quality of ideas from interacting in a diverse group (Paulus & van der Zee, 2015).

The literature on diversity and group creativity is relevant to schools. These are becoming increasingly diverse along racial, ethnic, and cultural dimensions. The potential benefit of diversity may not be realized without intensive interaction in structured settings. Collaborative creativity sessions can provide just such an opportunity. However, people from different cultures may approach creativity in different ways, which may help or hinder creativity. For example, children from collective cultures may be more effective in collaborative settings than those from individualistic cultures and thus may demonstrate higher levels of collaborative creativity (cf., Rogoff et al., 2017).

9.7.1 Culture and Creativity

Values of collectivism such as interdependence, conformity, and high power distance result in lower levels of creativity in idea generation phase of innovation (Goncalo & Staw, 2006). Individualistic cultural values are more beneficial when creativity is the goal since these emphasize independence and uniqueness as opposed to harmony and conformity (Goncalo & Staw, 2006). Because critical thinking and deviant responses tend to be suppressed in collectivistic cultures, this should negatively impact the originality of ideas generated. However, one can also argue that the creative outcome in such cultures is possibly geared towards refinement of existing ideas to make them more suitable for implementation. Kaplan, Brooks-Shesler, King, and Zaccaro (2009) reported that team conformity that is associated with greater coordination, information sharing, and a lower level of conflict are beneficial in the implementation stage of innovation. Paulus, van der Zee, and Kenworthy (2016) argued that cultural diversity would only enhance team performance in the context of task-related diversity. Team members from different cultures may generate dissimilar culturally relevant ideas on the same task, which can contribute towards a diverse pool of ideas.

Given cultural differences in approaches to creativity, differences among group members in the preference for uniqueness versus elaboration (or refinement) and collectivism versus individualism may complicate the collaborative creative process. Conflicts could rise and difficulty in developing consensus could develop. However, conflict may be more problematic in short-term groups, as members in longer term groups may learn to use their different orientations to enhance the group's outcomes (Watson et al., 1993). Studies have also reported that diversity faultlines, which are cases in which group members differ on several correlated dimensions of diversity such as gender and race, can negatively impact collaborative creativity (Ellis, Mai, & Christian, 2013), mostly due to conflicts (Homan, van Knippenberg, Van Kleef, & De Dreu, 2007). However, if the salience of faultlines is minimized or removed, the creative potential of groups can be enhanced (Jehn & Bezrukova, 2010).

In the past three decades, cross-cultural researchers primarily focused on comparing eastern and western cultures based on self-reports. With the terrain of culture being much wider today (Kitayama & Salvador, 2017), the definition of *culture* is now extended to one's values, experiences, background, and neurobiological level. Each of these dimensions may be independently relevant to an individual's creativity. If individuals in a certain culture are bilingual, they can have more creative potential in terms of sharing unique ideas by activating unique concepts through each language (Blot, Zarate, & Paulus, 2003).

9.8 Recommendations for Diversity and Collaborative Creativity

With the increasing diversity of backgrounds and cultures among student population in schools, sensitizing students and teachers to the benefits of diversity has become an important issue in education. Although inevitable challenges exist due to increased diversity, the research on collaborative creativity suggests that diversity can be a positive factor for group outcomes. We present some practical interventions that can help in making the best use of diversity in the current education settings with diverse populations.

1. On tasks that tap underlying cognitive differences related to diversity, increased diversity of ideas of group members can enhance collaborative creativity.
2. Positive outcomes of collaborations with diverse members should enhance the positive attitudes to diversity and the feelings of collective creative efficacy (Tasa, Taggar, & Seijts, 2007). This collective efficacy can then carry over to other school contexts.
3. Faultlines in educational settings may enhance problems related to diversity. For example, if a minority group is primarily female, this may make it harder for groups to have interactions in with both males and females of this group. In group contexts, attempts should be made to compose groups in ways to minimize such faultlines.
4. Taking advantage of diversity is critical to success. Organizations and educational institutions are becoming more culturally diverse and students from different cultures may have different orientations to creative tasks. Such differences can add to potential group conflicts. Hence, it is important to sensitize students to the potential benefits of collaborative creativity through various positive group experiences.

9.9 Research and Practices in Classroom

In the corporate world, managers are under constant pressure to create unique products catering to the needs and requirements of consumers. For example, IDEO Corporation, a design firm, focuses on unstructured group brainstorming to create new products. However, "educational researchers have paid very little scholarly attention to the recent shift to an innovation economy, although it has substantial implications" (Sawyer, 2006, p. 41). Sawyer (2003) underscored the value of team-based creativity in educational settings, suggesting that since it is initially difficult for some students to engage in collaborative work, they need to be taught and scaffolded to participate in groups.

A major gap in the creativity literature is research on collaborative creative processes among school children. Some literature that promotes a focus on creativity in individuals indicates that the role of education has often been blamed for "killing" creative potential (e.g., Kaila, 2005). Beghetto (2010) reported that creativity researchers have primarily worked to enhance creativity among gifted and talented children. Consequently, very small numbers of students from the mainstream academic curriculum have the opportunity to develop their creative potential in classrooms. Teachers of mainstream curriculum may not be working to foster and nurture student creativity if they see this as outside of their responsibility. Beghetto (2010) speculated that this could be the reason why policies fail to include the development of creativity in American school curricula (e.g., No Child Left Behind).

According to O'Donnell and Micklethwaite (1999), publicly funded primary and secondary schools in several Canadian provinces (e.g., Alberta and Ontario) began emphasizing the inclusion of problem solving, creativity, and critical thinking in preparing for work and lifelong learning and citizenship. Their report also reveals that a desirable learning outcome in England's school curriculum is the development of children's imagination and the ability to communicate ideas in creative ways. Some other countries that these researchers indicate have been emphasizing creativity in the form of dance, drama, music, visual arts, and critical thinking in their school curriculum are Singapore, the Netherlands, Spain, New Zealand, and the United States.

In China, the creative processes in past few decades had been based primarily on beliefs more than knowledge base (Mullen, 2018). However, there has been a rising interest in enhancing creativity among Chinese students (Mullen, 2017). Mullen (2018) reported that explicit instructions provided to foster creativity in a collaborative setting were highly valued by Chinese students. Hu et al. (2011) emphasized the importance of the Learn to Think curriculum for primary school children in China. They experience the combined approach of skills training in basic thinking, problem solving, and creative thinking. Academic achievements had reportedly improved for the children. Hu et al. (2013) later compared this model (experimental condition) with a regular curriculum (control condition) among secondary school children. After 2 years of intervention, the experimental groups developed significantly higher scientific creativity than the control groups. Thus, the above findings imply the emerging awareness of the importance and promotion of creative thinking among young adolescents in the educational settings of China.

A popular approach to team-based learning and creativity in Italian provinces is the Reggio Emilia approach of early childhood education (see Hong, Shaffer, & Han, 2017; McNally & Slutsky, 2017). This fosters collaboration for problem solving through critical thinking and idea sharing (brainstorming) among group members. Teachers facilitate children's thinking and create an environment that lends itself to research, problem solving, and group interaction. As opposed to promoting independence and individualism, the goal of this approach is to transform personal learning experience into a shared context where children develop a sense of self in group contexts (McNally & Slutsky, 2017).

A common trend in the above studies and in the field of education in general is that most scholars believe that creativity is an important individual trait that can be enhanced through training or facilitation. However, to the best of our knowledge, education in collaborative creativity remains surprisingly understudied along with a deeper exploration of factors affecting such creativity among school children. Yi, Hu, Plucker, and McWilliams (2013) reported that divergent thinking scores of middle school children were significantly lower than elementary children in China. They attributed this decline in creativity to the social pressures on Chinese children from the middle school level to prepare for competitive college entrance exams. Hence, these researchers noted that the creative organizational climate of school environments needs to support the fostering of children's creativity. We now turn to the application of creativity in various disciplines of education at the university level.

9.10 Creative Learning in Engineering

In the engineering education field, emphasis is on serving global learners of engineering through creative assignments that engage solving problems by using materials from other courses and disciplines (Felder & Silverman, 1988). Several researchers (Hernandez, Schmidt, & Okudan, 2013; Ilevbare, Probert, & Phaal, 2013) noted the importance of the theory of inventive problem solving (TRIZ), a method whereby one converts a specific problem to a general one bringing in a very large pool of ideas from various patents and other sources and fields (a generic perspective). Finally, one maps out the specific solutions (a specific perspective) from the generic framework. Hernandez et al. (2013) reported a significant positive effect of the TRIZ method in generating ideas of high novelty and variety (but not quantity) compared to the traditional brainstorming method among engineering students. The effectiveness of TRIZ also depends on the type of task and problem at hand. This method should be more effective when trying to come up with a breakthrough product or solution, which differs from a situation where the focus is on refining an existing product or concept to make it more effective or useful. Ilevbare et al. (2013) reported that TRIZ is primarily applicable to technical problem solving and innovation.

Dym et al. (2005) emphasized the value of divergent and convergent thinking in design engineering. They argue that divergent thinking is most applicable in contexts where concepts or answers do not have truth-value or verifiable answers. Although there is no systematic literature on collaborative creativity in engineering, most high tech companies depend on a great deal of collaboration in the engineering process. Thus, it is important to incorporate experiences in collaborative creativity in both the divergent and convergent phases in engineering education.

9.11 Creativity in Medical Sciences

The literature on collaborative creativity is very limited in the medical education field. Despite major advances in medical technology, efforts to promote new interactive techniques of teaching have been slow (Geuna & Giacobini-Robecchi, 2002). Some researchers note that medical education lacks integrative and collaborative learning brought in by students from diverse backgrounds in a collaborative environment (e.g., Irby, Cooke, & O'Brien, 2010) and that investments in health care are necessary for research and innovation (Asch & Weinstein, 2014).

We turn to some common practices used in medical education. One of these is problem-based learning, used as a pedagogical approach in medical science for several decades. *Problem-based learning* can be defined as a collaborative method of learning in which students learn through "actively solving problems rather than passively absorbing information" (Nandi, Chan, Chan, Chan, & Chan, 2000, p. 302).

Although this type of learning has received considerable attention as an effective pedagogy in medical education, some researchers have found no difference between problem-based learning and traditional learning in this field (Nandi et al., 2000). Hmelo-Silver, Duncan, and Chinn (2007) have concluded that the extensive “scaffolding” used in problem-based learning in educational settings effectively reduces cognigerdtive load and thus enhances learning.

Handfield-Jones, Nasmith, Steinert, and Lawn (1993) emphasize the importance of experiential learning, role play and “medi-dramas” as effective pedagogical practices in medical sciences. Others have used brainstorming in teaching human anatomy to nursing students, finding that more than 50% of these participants perceived brainstorming as very effective (Geuna & Giacobini-Robecchi, 2002). Another group of researchers (Goswami, Jain, & Koner, 2017) used brainstorming with postgraduate medical students, citing its effectiveness in enhancing understanding of biochemical concepts. While some researchers found that the use of storytelling in problem-based learning is a benefit to students’ reflective learning in dentistry (e.g., Kieser, Livingstone, & Meldrum, 2008), others point to the effectiveness of concept mapping that has been incorporated in problem-based learning in medical education (Daley & Torre, 2010). Thus, apart from some efforts in using creative ways of teaching, the evidence regarding efforts in collaborative creativity in medical education is very limited.

9.12 Creativity and Music Education

Great symphony orchestra performances require creativity not only from the composer and the conductor but also from every musician (Salonen, 2008). The importance of collaborative creativity in music performance is evident in MacDonald and Miell’s (2000) study in which they created dyads of children consisting of friends or non-friends, having them generate a piece of music. Teachers rated the dyads’ compositions by friends of significantly higher quality than of those in non-friendship pairs. These researchers suggested that social relationships play a crucial role in collaborative creativity involving music among children because of the importance young people place on music.

MacDonald, Davies, and O’Donnell (1999) subjected participants with special needs to an 18-month music workshop. Workshop participants exhibited higher performance motivation and expressed ideas of greater value than those not exposed to a music workshop. Sawyer (2015) promoted the importance of teaching music in collaborative contexts as opposed to solitary contexts for enhancing musical performance among children. He reports that three characteristics play key roles in group creativity: improvisation, collaboration, and emergence. Improvisation is valued when a group member commits an error and the other performers make up for the mistake. In such a context of “group flow,” group members inspire each other, playing a crucial role in overall performance.

Several music toys have been created to promote enhanced learning of music among children in schools. For example, Sawyer (2006) reported that Beatbug is one such toy designed for playing with a group of eight participants. Use of such toys has enhanced interaction and communications among players. Through the practice of scaffolding and guided participation, teachers can enhance students' musical performance in such group-learning contexts.

9.13 Summary of Research in Educational Settings

We have reviewed the literature on collaborative creativity in general and on creativity in education. Although considerable literature on group creativity exists and some on creativity in educational settings, research on collaborative creativity in educational settings is very limited. The educational environment has lacked a strong focus on creativity. Concern with maintaining order in schools and meeting various achievement goals also restrict the attention on creativity. Creativity and critical thinking are difficult to teach and few have the ability or confidence to teach, encourage, or facilitate collaborative creativity. We provide some insights from our review and suggestions for enhancing the practice of creativity in educational settings.

1. Creativity in education seems to be valued in many countries. Research demonstrates broad benefits of programs for enhancing creativity in children. However, thus far we know of no research on collaborative creativity involving children. This is unfortunate since they may especially enjoy such activities, which in turn can help build their social, collaborative, and intellectual skills.
2. Project-based learning is emphasized in engineering pedagogy. Such team-based education should help build collaborative skills needed for working in creative groups. However, we know of no research that demonstrates such a link.
3. Many engineering problems require diverse collaborative inputs. Thus, experiences in collaborative creativity in engineering education would seem to be quite important.
4. Teaching pedagogy in medicine commonly follows traditional, problem-based, and group based learning approaches. Even though some medical practices involve teamwork and collaborative problem solving, there is little obvious weight given to training collaborative teamwork or creativity skills in this domain.
5. Some research in music education demonstrates benefits of creative collaboration, which suggests the importance of incorporating collaborative creativity experiences in the music curriculum.
6. Effective communication among team members is important in creativity, particularly in new product development teams. Therefore, educational programs should incorporate training on stimulating and managing communication in groups.

7. Learning occurs on a deeper level when materials provide for a variety of potential explorations. An assessment method that tests students' engagement in divergent and convergent inquiry on a given problem can be helpful in promoting flexibility with using knowledge.
8. Educators should be encouraged to develop their skills in enhancing both individual and collaborative creativity. This should be beneficial at all levels of the educational spectrum from elementary school to universities and professional schools.

9.14 Conclusions

Although there is a significant literature on creativity in education and its role and benefits, there is very little on collaborative creativity in education. In some disciplines, there are efforts to employ creative methods of teaching, but there are very few reports of systematic attempts to enhance students' creativity.

Research in education focuses on obtaining knowledge in specific areas, but without attending much to using this knowledge for creative exploration. Achievement tests focus on mathematical and verbal abilities rather than creative abilities. Yet, research indicates that intelligence and high grades in school are only moderately related to career success. The average correlation between intelligence and performance at job is low (from .2 to .4) (Wigdor & Green, 1991). Furthermore, intelligence is not related strongly to creativity (Sternberg & O'Hara, 1999), although a minimum level of intelligence may be a necessary condition for creativity (Jauk, Benedek, Dunst, & Neubauer, 2013).

While the world needs knowledgeable and intelligent citizens, there is also a great need for creativity to solve problems and develop innovations. This increasingly requires effective collaboration with others and in diverse groups. Our literature review suggests that there is some evidence of the benefit of creativity programs (e.g., Learn to Think) in primary school systems in China (Hu et al., 2011). However, we know of no research on training in collaborative creativity in schools and the potential benefits of such training in broader contexts.

However, the importance of teamwork skills for working effectively in group settings has been examined intensively (e.g., Paulus, Dzindolet & Kohn, 2012). There is also recent research on the importance of group level skills for effective group functioning. For example, in a study of groups across a range of tasks it was found that the groups functioning the best had equal distribution of conversational turn taking among group members and higher levels of interpersonal empathy or social sensitivity (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010). Individual intelligence of the group members had no impact on group performance in this study. Woolley et al. (2010) have termed such a cluster of group traits "collective intelligence."

Educational environments should encourage students in collaborative creative activities and other group tasks in order to allow for a development of group skills and collective intelligence. This kind of development is required for success in collective endeavors that are important in the workplace, research groups, and educational settings. Research on group creativity provides much valuable information for guiding the application of group creative activities in school settings.

We end with additional suggestions of our own:

1. To the extent feasible, collaborative exercises should be incorporated into the curriculum to develop students' ability for working effectively in group settings or for generating collective intelligence.
2. Besides encouraging individual creativity in courses at the primary and secondary level, opportunities should be provided for collaborative creativity experiences as well. In addition to sharpening students' collective and creativity skills, such experiences can enhance feelings of confidence in these domains (collective and creative self-efficacy) (Tasa et al., 2007). A combination of enhanced skill and self-efficacy should greatly increase the potential for effective collaboration in and out of school settings.
3. It would also be helpful if teachers and other staff learned effective procedures for creative problem solving to enhance their own educational efforts. Periodic training and workshops for educators on newer methods of collaborative innovation should be helpful in promoting creativity in educational environments and applying collaborative creativity exercises in the classroom.
4. Specialized team skill training at the school level should sensitize students about the best use of the environmental context (e.g., diversity, group size, and brainstorming paradigm) for enhancing collaborative creativity.

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