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Abstract

The purpose of this systematic review is to reveal the research findings that suggest instructional practices to foster the creativity of students in mathematics. Although several studies have investigated the effects of various instructional practices influencing the mathematical creativity of students, little is known about how the findings of this collective body of research contribute to the understanding of what instructional practices should be integrated into a mathematic classroom to further foster the mathematical creativity of students. In this systematic review, the knowledge of instructional practices that foster the mathematical creativity of students were categorized under two main factors including: 1) discipline-specific instructional practices and 2) general instructional practices. The discipline-specific instructional practices were problem-solving, problem-posing, open-ended questions, multiple solution tasks, tasks with more than one correct answer, modeling/model-eliciting activities, technology integration, extendable tasks, and emphasizing abstractness of mathematics. The general instructional practices were providing students with ample time to think creatively about real-world related mathematical problems in a judgment free and collaborative classroom environment so that they take risks to share their mathematical ideas and use informal words. Integrating all of these instructional practices into mathematics classrooms can provide opportunities for students to discover their potential creative abilities in mathematics.

Introduction

Creativity traditionally was solely associated with art and literature; however, researchers are currently paying attention its importance in mathematics and other STEM-related disciplines (Neumann, 2007; Sriraman, 2005). Creativity, for example, is seen as a necessary condition for the growth of the field of mathematics (Sriraman, 2004; Sriraman, 2009). Although several mathematics education researchers have emphasized critical nature of being creative in mathematics (Chamberlin & Moon, 2005; Ervynck, 1991; Mann, 2006; Piirto, 1998; Sternberg 1999; Sriraman, 2005), no consensus has emerged on the definition of mathematical creativity. The reason why various definitions of mathematical creativity exist is because two distinct approaches exist regarding the meaning of general creativity (Harpen & Sriraman, 2012).

Historically, the more common approach was that creativity is an exceptional ability to discover divergent ideas in domain general that an individual can attain effortlessly (Guilford, 1959; Weisberg, 1988). This approach of creativity is very limited in terms of its educational implementations because this approach implies that creative abilities are not influenced by any conditions (e.g., instructional practices, environmental and social factors) other than the innate characteristics of individuals. However, a newer approach of creativity that has emerged opposite the predominant association of creativity with the notions of "genius". Based on this newer approach, creative abilities are rather been associated with individuals' effort and commitment in domain specific and domain general (Holyoak & Thagard, 1995; Stemberg, 1988; Silver, 1997).

Many educators in mathematics have adopted this approach (Stenberg, 1988; Silver, 1997) because this approach has numerous educational implementations and provides educational opportunities for all students to enhance their creative abilities in mathematics rather than only a few exceptional ones (Silver, 1997). Within the adoption of the new version of creativity approach into mathematics education, scholars have redefined mathematical creativity as an ability to: generate original mathematical products (Sriraman, 2009), originate useful and new solutions to mathematical problems (Chamberlin & Moon, 2005), and solve mathematical problems by discerning an original and insightful solution methods (Sriraman, 2004; Ervynck, 1991; Haylock, 1987).

One conflict among these definitions is about whether creative products should be useful. For example, Sriraman (2009) argued that a product of creative mathematical work does not necessarily need to be useful in terms of its direct or indirect applications in the real world, but it is sufficient if the mathematical product is imaginative and original. In addition, all of the definitions provided were relevant to adults who are forefront in the field of mathematics (Chamberlin & Moon, 2005; Shriki, 2010) who generate novel and useful mathematical ideas. However, defining mathematical creativity only by emphasizing novelty and usefulness was not practical for the development of mathematical creativity of school students (Shriki, 2010). Sriraman (2009) distinguished between the creativity of professional mathematicians and K-16 school students because "… a student's discovery of a known results of innovative mathematical strategy can also constitute creativity" (Shriki, 2010, p. 161). By adopting the features of the newer approach of creativity that an individual can develop his/her creative abilities through effort and commitment along with considering the key components of each provided definition of mathematical creativity, this present study seeks to provide a common definition for future studies investigating the mathematical creativity of students.

The present study thus provides a definition of mathematical creative ability at K-16 school level as "an ability to generate new mathematical ideas, processes, or products that are new to the students but may not necessarily new to the rest of the world, by discerning and selecting acceptable mathematical patterns and models." Because the emphasis of this definition is on the intellectual development of students in mathematics rather than on developing novel or useful mathematical products, this definition will further support mathematical equity as "the implication for equity in mathematics education is that all learners should have access to mathematics education that promotes their creativity which would consequently have an impact on their future success" (Wessels, 2014, p. 22).

Scholars in the field of mathematics education have already suggested various school-level interventions that teachers can implement to foster their students' mathematical creative abilities. These interventions include but are not limited to problem-posing (Ellerton, 1986; English, 1997; Jensen, 1973; Kopparla et al., 2018; Krutetski, 1976; Silver, 1994; Silver, 1997), problem-solving (Bicer & Capraro, 2019), and model-eliciting activities (Chamberlin & Moon, 2005). Although several studies have suggested various instructional practices that have been shown potential to foster the mathematical creativity of students, little is known about how a collective body of research findings contributed to our understanding of what instructional practices should be integrated into mathematics classrooms to further foster the mathematical creativity of students (Bicer, Chamberlin, & Perihan, 2020). In the present study, we defined instructional practices in mathematics classrooms as tasks (e.g., problem solving) and methods (e.g., collaboration) that guide interaction in the classroom.

The present study seeks to answer the following research question: What instructional practices were suggested to foster K-16 students' mathematical creativity? This systematic review will examine a collective body of the suggestions of previous research related to instructional practices that foster the mathematical creativity of students. Revealing these practices collectively can help mathematics teachers integrate the suggested instructional practices into their classrooms. Implementing these instructional practices in mathematics classrooms may also increase equitable thinking among students, and ultimately promote equity in the school community (Bicer et al., 2020; Luria & Kaufman, 2017).

Theoretical Framework

General and Mathematical Creativity

Creativity was originally considered as one of the subdimensions of intelligence and individuals who are able to find unique ideas or modify the existing ones were considered as cognitively flexible (Deak, Ray, & Pick, 2004; Guilford, 1967). While some psychologists viewed creativity as a cognitive flexibility in domain general (e.g., Guilford, 1959), some viewed it as a cognitive flexibility in domain specific (Harpen & Sriraman, 2012; Plucker & Zabelina, 2009). Guilford (1959) hypothesized that general creative thinking included four important segments including fluency (the number of generated solutions), flexibility (the diversity of generated solutions), originality (the uniqueness of the generated solutions), and elaboration (the level of detailed steps to make a generated plan work). Most creativity tests scholars use in today have been based at least partially on Guilford's (1959) creativity theory. For example, Torrance (1966) developed a test to measure the creativity of individuals in general domain by applying Guilford's four factors of creative thinking. Later, Torrance (1974) redeveloped the test and named it as Torrance Tests of Creative Thinking [TTCT]. This test has been one of the most commonly applied instruments by scholars to measure general creativity. There are two forms of TTCT as Figural and Verbal. Although both forms were intended to measure creativity differently, there was found little correlation (r =.06) between scores on the two forms (Torrance, 1990). Kim (2011) and Baer (2009; 2011) agreed that the reason of little correlation between two forms of creativity was because these two were together aimed to measure individuals' general creativity, but each measure individuals' different cognitive skills. These were indications of creativity as domain-specificity that many scholars (e.g., Henri Poincare (1948), Jacques Hadamard (1945), and Garrett Birkhoff, 1956) in specific field argued. In the present study, we adopted creativity as a domain-specific by focusing on creativity in mathematics. Researchers specifically characterized creativity in mathematics as a domain-specific by employing mathematical tasks that they can observe: 1) non-algorithmic decision making (Ervynck, 1991), b) flexible thinking ability to solve problems more than one way (Haylock, 1997), and c) generating unusual solutions to a given mathematical problem (Bicer et al., 2020; Sriraman, 2009).

Creativity as domain specific gained the attention of mathematicians (e.g., Henri Poincare (1948), Jacques Hadamard (1945), and Garrett Birkhoff, 1956), and they were mostly influenced by the Gestaltian steps of creative actions, which were categorized as preparation, incubation, illumination, and verification (Wallas, 1926). Gestalian steps of creative actions were the inception of creative dialogue that were considered as one of the most important contribution to the discussion of creativity. Wallas (1926) developed this four-stage process of general creative actions in a way that it can be applied to specific domains. In the phases of Gestalt creativity, preparation is the investigation of a problem consciously; incubation is thinking about a problem unconsciously, illumination is attaining an idea abruptly and unexpectedly, and verification is the validation of an idea consciously. Poincare (1948) emphasized the necessity of both unconscious (incubation, illumination) and conscious (preparation and verification) processes for creative actions by saying that one step never takes place without the existence of the other (Hadamard, 1945; Sadler-Smith, 2015). Mathematicians were heavily influenced by the Gestalt method of creativity (Hadamard, 1945) and a recent study conducted by Sriraman (2004) confirmed that the creative mathematicians still used the Gestalt method of creativity. Additional methods were also suggested to describe and measure the process of mathematical creativity. For instance, Getzels and Jackson (1962) assessed the mathematical creativity of students with problem posing tasks that required multiple arithmetic operations and solutions.

Although diverse suggestions have been made to describe and measure the process of mathematical creativity, researchers in the field of mathematics education have predominantly adopted the psychology approach of creativity and proposed several combinations of four commonly known factors (fluency, flexibility, originality, and elaboration) to measure the mathematical creativity of individuals in various educational contexts (Balka, 1974; Bicer et al., 2020; Kattou et al., 2013; Leikin & Lev, 2013; Silver, 1997; Sriraman, 2004). Balka (1974) initiated the adoption and applied the notions of fluency, flexibility, and novelty in the field of mathematics and interpreted them thusly. Fluency is the number of generated solutions to a given problem, flexibility is the number of various approaches to solve a problem, and the novelty is the number of rare solutions compared to solutions of specific set of people (e.g., classrooms, schools) (Ervynck, 1991; Leiking & Lev, 2007; Silver, 1997). In subsequent years, Haylock (1987) and Singh (1988) also measured the mathematical creativity of students in the context of mathematical problem solving with respect to fluency, flexibility, and novelty.

Researchers mostly have agreed that mathematical creativity should be considered in the context of mathematical problem-solving and/or -posing. Problem-solving and -posing activities reported as a mediator of mathematical creativity (Silver, 1997). In the context of problem-posing and problem-solving, mathematical creativity was mostly considered as overcoming mental fixations so that students can either solve problems by breaking away from stereotypical solutions (Haylock, 1997) or pose an open-ended problem that can be solved through multiple ways and have multiple correct answers (Silver, 1997). Krutetski (1976) also noted that mathematical creativity can be manifested when individuals are expected and encouraged to use alternative solution methods and/or create unique ways to solve mathematical problems by breaking away from the traditionally practiced common solutions.

Cognitive Flexibility

For individuals to break away from stereotypical solutions, they should have cognitive flexibility. Cognitive flexibility is the ability of an individual to activate and modify his or her cognitive processes as task demands are changed (Deak et al., 2004; Krems, 1995). Cognitive flexibility consists of three constructs as cognitive variety, cognitive novelty, and modification in cognitive framing (Furr, 2009). Cognitive variety is the diversity of cognitive pathways or mental structures for problem solving (Eisenhardt, Furr, & Bingham, 2010). Cognitive novelty is the bringing additional external perspectives (Furr, 2009).

The successful experiences of individuals in problem-solving may lead them to change their cognitive framing (Singer & Voica, 2015). Cognitive framing occurs when an individual utilizes an effort and commitment to solve a new problem by using a previously practiced solution strategy (Goncalo, Vincent, & Audia, 2010) rather than adopting or discovering new approaches. Haylock (1997) noted that students should overcome fixations (e.g., content-universe fixation and algorithmic fixation) in mathematics so that they can be mathematically creative. Balka (1974) included overcoming fixation is one of the necessary indicators and criteria to be mathematically creative.

Modification in cognitive frame is a necessary condition for individuals to be creative in mathematics that enables them to have the ability to break away from established mental structure to attain creative mathematical solutions (Voica & Singer, 2013). Almost all mathematical creativity measures include flexibility and being flexible to change thinking frame when mathematical task demands are modified is vital to take creative actions in mathematics (Haylock, 1997). Helson and Crutchfield (1970) conducted a study to understand the relationship between being flexible and creative in mathematics. This study revealed that mathematicians who were ranked by other mathematicians as being more creative attained statistically significantly higher scores in terms of being more flexible to modify their established mind sets than their peers who were ranked as less creative in mathematics. By considering previous research findings, it is possible to conclude that being creative in mathematics necessitates being able to modify cognitive thinking frame in mathematics.

Creativity and Equity

The relationship between creativity and equity was investigated by scholars (e.g., Goclowska, Crisp, & Labuschagne, 2013; Tadmor, Chao, Hong, & Polzer, 2013). Equity in that context was mostly operationalized as an individual's stereotype. For example, Goclowska et al. (2013) found that individuals who were challenged to change their stereotype-image in a certain field (e.g., mathematicians, lawyers) demonstrated higher cognitive flexibility than individual who were not challenged. Another study conducted by Tadmor et al. (2013) also reported similar finding that individuals who had racial stereotype-image in certain fields were less creative regardless they were from traditionally upper class or underrepresented subpopulation. Luria et al. (2017) explained this by stating that "one of many possible explanations is that endorsing stereotypes (especially negative ones) may indicate a more rigid way of thinking, which is inconsistent with the flexibility and open-mindedness that is often needed for creativity occur" (p. 1033-34). Indeed, researchers (e.g., Kaufman, 2016; Kwon, Park, & Park, 2006) noted that the importance of openly thinking rather than rigid thinking to be creative by affirming that a person can manifest his/her creative thinking by generating ideas to open-ended questions. Openly thinking as related to creative thinking were considered as a vital dimension of enhancing equitable educational, social, and economic opportunities to individuals (Richmond, 2014).

Considering general or mathematical creativity as one of the potential criteria while admitting students to college, graduate schools, and gifted education programs can reduce bias in education (Kaufman, 2015). Students were mostly accepted to such programs through standardized tests and research often reported statistically significant differences favoring students who come from traditionally upper-class background over students who come from underrepresented subpopulation (Bleske-Rechke, & Browne, 2014). On the other hand, researchers (e.g., Baer & Kaufman, 2008; Kaufman, 2016) found no statistically significant differences on creativity test by students' gender and ethnic backgrounds. In addition, Kaufman (2016) noted that students from underrepresented subpopulation achieved higher score on creativity tests than students from traditionally upper class. These results showed that embedding mathematical creativity in admissions can increase equity and reduce bias (Luria et al., 2017). For example, Sternberg (2008) observed that after Tuffs University included creativity as one of the admission criteria, minority enrollment increased.

Including creativity as one of the admission criteria to such programs has potential implications for classroom practices because teachers give more importance to a construct that is tested to decide which students get into college, graduate schools, and gifted education programs (Luria et al., 2017). Unfortunately, many teachers in the traditional mathematics classrooms have ignored creativity and conceptual understating of mathematics because their major focuses were to develop students' procedural learning of mathematics that enables students to solve problems through imitating prototype solutions step-by-step process. This was not surprising because mathematical creativity in education was mostly emphasized lately starting in 21st century and changing curriculum materials and teachers' current practices are a long process requiring continues educational professional development series. That being said, it was reported that most teachers have not been aware or had very limited perspectives of research-suggested instructional practices that promote students' mathematical creativity (Bolden, Harries, & Newton, 2010; Leikin & Pitta-Pantazi, 2013; Shriki, 2010) partly because most of them lack prior experiences of engaging with creative tasks in their college mathematics and mathematics education courses (Mann, 2006; Shriki, 2010). Therefore, this study will help teachers be aware of what research suggested instructional practices are for promoting students' mathematical creativity.

Methodology

A systematic review was conducted to establish reliable evidence-based suggestions related to instructional practices influencing the mathematical creativity of students. A systematic literature review is "a scientific process governed by a set of explicit and demanding rules oriented towards demonstrating comprehensiveness, immunity from bias, and transparency and accountability of technique and execution" (Dixon-Woods, 2011, p. 332). Although systematic reviews have been criticized as limiting potential findings (MacLure, 2005), they do offer potential benefits like converging quantitative and qualitative research findings together. This is a methodologically need because other commonly used analytic methods only cover either qualitative or quantitative paradigms. For example, while meta-analysis presents only findings from quantitative approach, meta-synthesis only interprets findings from a qualitative approach. Merging both qualitative and quantitative studies through a systematics review, therefore, offers an effective model to report a broader perspective and strengthens the review of research questions.

The following research question drove this systematics review: What instructional practices are suggested to foster the mathematical creativity of K-16 students? To answer this question, a systematic literature review was utilized because the findings of both qualitative and quantitative research suggested that various instructional practices foster the mathematics creativity of students and these should be considered simultaneously as a collective body of research. Evidence for Policy and Practice Information and Co-ordinating Center EPPI-Centre's (2007) seven steps of systematic review process was followed to ensure that the literature review was indeed systematic. Following these seven steps suggested by EPPI-Center were shown to provide a robust evidence based for identifying instructional practices promoting mathematical creativity of students. EPPI-Centre provide training, support and quality assurance to scholars all around the world to ensure that their review processes and products are replicable, reliable, and sustainable (Sebba, Crick, Yu, Lawson, Herlen, & Durant, 2008).

The first step in the process was developing the inclusion criteria. The inclusion criteria were: the literature must be about creativity in mathematics, the literature must suggest at least one type of instructional intervention related to mathematical creativity, the literature must be related to K-16 students, and the literature must be published after peer-reviewed process as journal articles, conference proceedings, and book chapters.

The second step was searching for studies. The author of the present study and a trained research assistant identified relevant studies in the literature through five scientific databases, namely, the Education Resources Information Center (ERIC), the Web of Science, Scopus, PsychINFO, and GoogleScholar. To reach a more comprehensive understanding of the theoretical groundworks and the practical uses of mathematical creativity, a broad search was used, utilizing the terms mathematical creativity, creativity in mathematics, students' mathematical creativity, creative abilities in mathematics, and mathematics and creativity. After searching with broad key words, specific key words were selected to ensure to find as many publications as possible relevant to the research questions. A search with specific key words included: creativity in mathematics classrooms, creative dispositions in mathematics, attitudes towards mathematical creativity, creative problem solving, creative mathematics teaching, creative mathematics instruction, creative behavior in school mathematics, creativity in elementary school mathematics, creativity in middle and high school mathematics, creative mathematics classroom environment, instructional practices fostering mathematical creativity, creativity and college mathematics, interventions fostering creativity in mathematics, assessing mathematical creativity, and creative mathematics curriculum. The initial search yielded 303 references. Eliminating the duplicates (n=93) resulted in 210 studies for the next phase.

The third step was screening studies based on inclusion criteria that was developed in the review step. Screening abstracts and full-text with the detailed inclusion criteria constantly reduces hidden bias towards certain studies that were being used to answer the research question concerning instructional practices that foster the mathematical creativity of students. First, each abstract was screened by the author and trained research assistant. In the case of question about the inclusion of an article, the research team reviewed all the decisions by screening the full-text. This resulted in 97 articles. Second, full-text screening of the remaining articles was conducted with the same inclusion criteria by two members. In case of concerns, the studies were assigned to an external reviewer. After the full screening process, 58 studies remained for in-depth analyses.

The fourth step is describing and mapping studies. In this case, studies were described and mapped based on their publication years, designs, research questions, type of the study, size of the study, and target groups. This process yielded a descriptive map showing the relationship among studies and their relevance to the research question (Harden & Thomas, 2005). Triangulation is the employment of multiple sources of data, observers, methods, or theories in exploring the same queries (Bednarz, 1986). The two researchers employed triangulation in an independent assessment of 20% of the studies to identify and eliminate potential bias (Campbell & Fiske, 1959).

The fifth step is the appraisal of quality and relevance. Each study was evaluated in terms of their consistency, data collection and analysis procedure, and trustworthiness of the results. For consistency, an inquiry was made to determine if the purpose of the research was aligned with the research questions, data, and data-analysis. With respect to data collection and analysis, the researchers determined if instruments for data collection and types of data analyses procedures were discussed. For trustworthiness, the studies were examined to understand if they reported reliability/dependability, external validity/transferability, and internal validity/credibility. Gough's (2007) criteria for judging weight of evidence were adopted to determine if the methodological quality of each study were excellent, good, satisfactory, and inadequate. As a result, 58 articles (see Figure 1) had adequate quality and were, therefore, included in this systematic review.

The sixth step is synthesizing the findings. To bring structured summaries of each study, a map was developed with respect to the suggested instructional practices of each study that influence mathematical creativity of students. When a study suggested more than one intervention aimed at increasing mathematical creativity of students, that study was listed under more than one practice. This process yielded the number of studies that suggested various instructional practices.

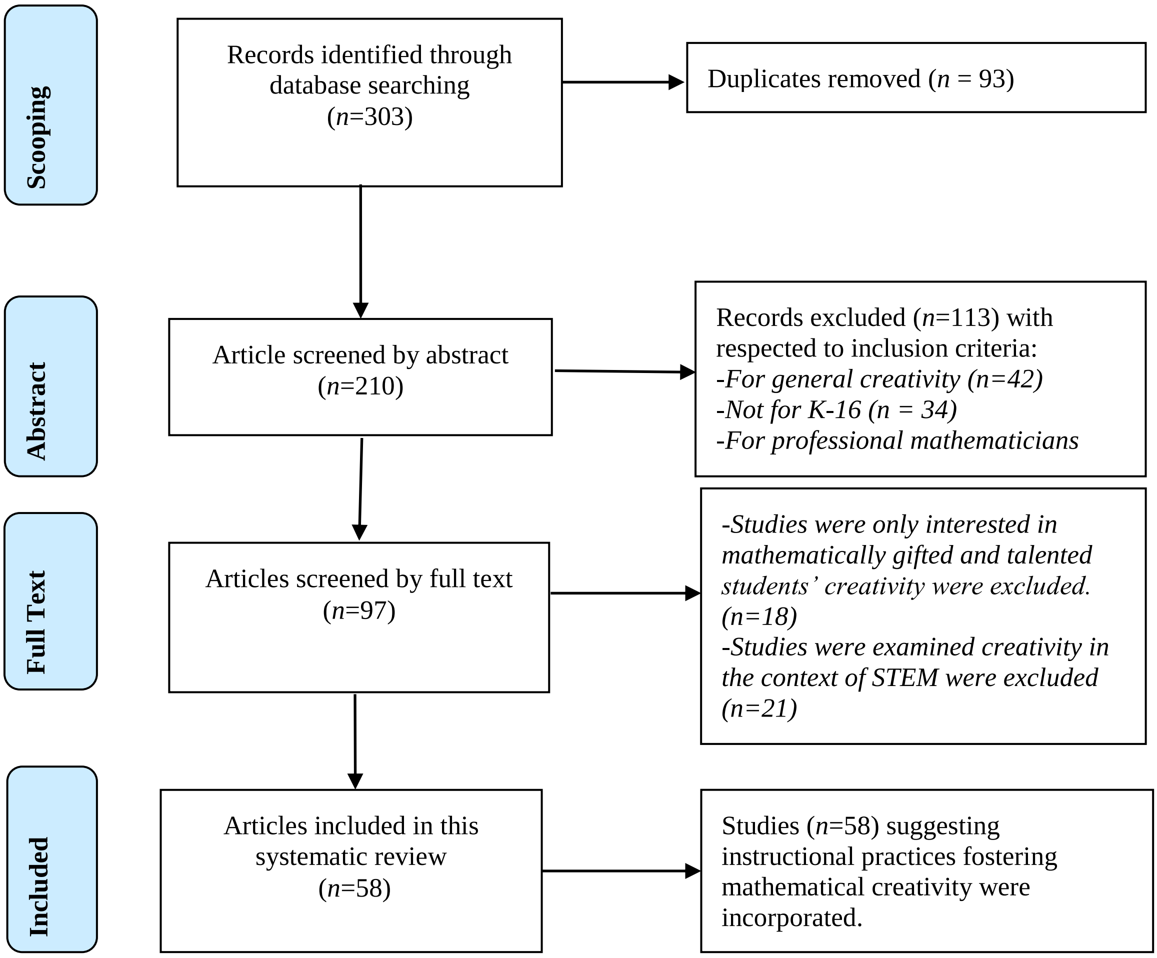

Figure 1. Selection of the Studies in this Systematics Review for the Mathematical Creativity of Students

The seventh step is providing conclusions and discussions. The current study summarized the suggested instructional practices that teachers could implement into their classrooms to increase the creative abilities of their students in mathematics. Lastly, the potential limitations in the generalizability or transferability of findings were discussed.

Findings

Fifty-eight of educational studies from our database discussed the instructional practices influencing the mathematical creative abilities of students. Among these studies, there are theoretical papers, empirical research finding, and case studies that were published in peer reviewed journals, conference processing, and book chapters. The evidence from the 58 studies addressing instructional practices that fostered the mathematical creativity of students fell into the two broad themes of disciplined specific and general instructional practices. It is also noteworthy to mention that discipline-specific and general instructional practices inform each other. General instructional practices can be considered as practices that teachers can implement while integrating one of the discipline-specific instructional practices into their mathematics classrooms (see Figure 2).

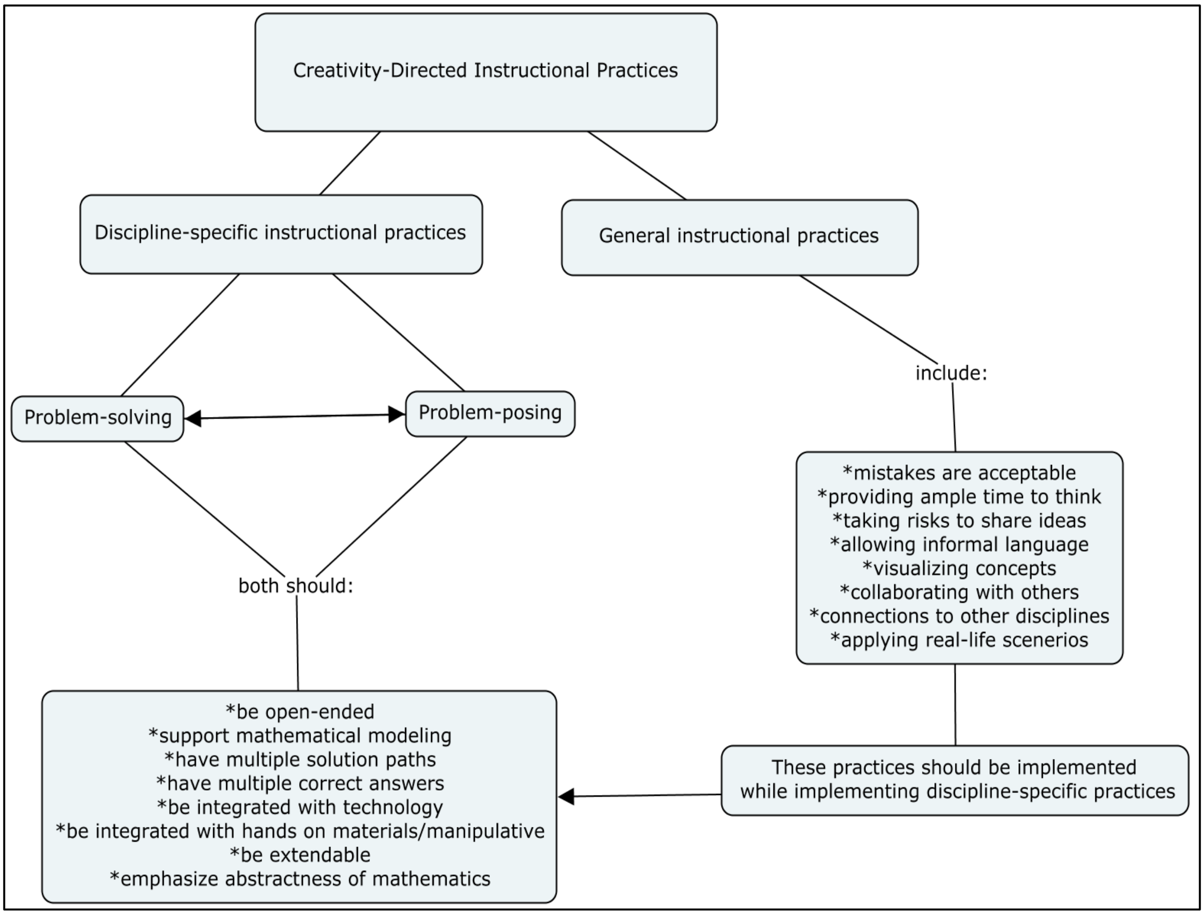

Figure 2. The Association of Themes emerged from the Present Study

Discipline-Specific Instructional Practices

Reasonable evidence across a number of studies suggested that the discipline specific instructional practices foster the mathematical creativity of students (e.g., Albert & Kim, 2013; Silver, 1997). The discipline-specific instructional practices that emerged were: problem-solving, problem-posing, open-ended questions, multiple solution tasks, tasks with multiple outcomes, modeling and model eliciting activities, technology integration (manipulatives, computers, and graphic calculators), extendable tasks, and emphasizing abstractness of mathematics (see Table 1).

Table 1. Year, Publication Type, and Suggested Instructional Practices of the Studies

#	Authors	Year	Publication Type	Suggested Instructional Practices
1	Albert, Kim	2013	Journal Article	○ Problem-Solving ○ Problem-Posing
2	Ayllon, Gomez, Ballesta-Claver	2016	Journal Article	○ Problem-Solving ○ Problem-Posing
3	Haylock	1997	Journal Article	○ Problem-Solving ○ Problem-Posing
4	Nadjafikhaha,Yaftian,		Journal Article	○ Problem-Solving

	Bakhshalizadehc	2012		○ Problem-Posing
				- Mistakes Free - Collaboration/Share Mathematical Ideas
5	Novita & Putra	2016	Journal Article	○ Problem-Solving
6	Pehkonen	1997	Journal Article	○ Problem-Solving ○ Technology Integration (Computer)
7	Saragih & Habeahan	2014	Journal Article	○ Problem-Solving
8	Silver	1997	Journal Article	○ Problem-Solving ○ Problem-Posing ○ Open-Ended Questions ○ Multiple Solution Tasks
9	Suastika	2017	Journal Article	○ Problem-Solving ○ Open-Ended Questions
10	Vale, Pimental, Barbosa, Cabrita,	2012	Conference Proceeding	○ Problem-Solving
11	Kandemir & Gur	2007	Journal Article	○ Problem-Solving ○ Problem-Posing
12	Sriraman	2005	Journal Article	○ Problem-Solving ○ Problem-Posing
13	Bolden, Harries, & Newton	2010	Journal Article	○ Problem-Solving ○ Problem-Posing
14	Kontorovich, Koichu, Leikin, Berman	2011	Conference Proceeding	○ Problem-Posing
15	Pelczer, Rodriguez	2011	Journal Article	○ Problem-Posing
16	Singer	2012	Book Chapter	○ Problem-Posing
17	Singer, Pelczer, & Voica	2011	Conference Proceedings	○ Problem-Posing
18	Yuan & Sriraman	2011	Book Chapter	○ Problem-Posing
19	Mann	2006	Journal Article	○ Problem-Posing ○ Open-Ended Questions ○ Abstractness of Mathematics
				- Enough Time
20	Van Harpen, Sriraman	2013	Journal Article	○ Problem-Posing
21	Hashimoto	1997	Journal Article	○ Open-Ended Questions
22	Kadir, Lucyana, Satriawati	2017	Journal Article	○ Open-Ended Questions
23	Kwon, Park, Park	2006	Journal Article	○ Open-Ended Questions

24	Suyitno, Suyitno, Rochmad, & Dwijanta	2018	Conference Proceedings	o	Open-Ended Questions
25	Wijaya	2018	Conference Proceeding	o	Open-Ended Questions
26	Yuniarti, Kusumah, Suryadi, & Kartasasmita	2017	Journal Article	o	Open-Ended Questions
27	Shriki	2010	Journal Article	o	Open-Ended Questions
28	Hershkovitz, Peled, Littler	2009	Book Chapter	o o	Open-Ended Questions Multiple Solution Tasks/Multiple Outcomes
29	Leikin, Lev	2007	Conference Proceeding	o	Multiple Solution Tasks
30	Livne, Livne, Wight	2008	Conference Proceeding	o o	Multiple Solution Tasks Open-Ended Questions
31	Tsamir, Tirosh, Tabach, & Levenson	2010	Journal Article	o	Multiple Solution Tasks/Multiple Outcomes
32	Levay-Waynberg, Leikin	2012	Journal Article	o	Multiple Solution Tasks
33	Amit, Gilat	2012	Conference Proceedings	o	Modeling/Model-Eliciting Activities
34	Coxbill, Chamberlin, & Weatherford	2013	Journal Article	o	Modeling/Model-Eliciting Activities
35	Chamberlin, Moon	2005	Journal Article	o	Modeling/Model-Eliciting Activities
36	Wessels	2014	Journal Article	o -	Modeling/Model-Eliciting Activities Enough Time
37	Siew, Chong	2014	Journal Article	o o	Open-Ended Questions Technology Integration (Hands on manipulatives)
38	Idris, Nor	2009	Journal Article	o	Technology Integration (Graphic Calculator)
39	Wardani, Sumarmo, Nishitani	2010	Journal Article	o -	Open-Ended Questions Collaboration/Share Mathematical Ideas
40	Carreira, Amaral	2018	Book Chapter	o	Problem-Solving
41	Manuel	2009	Book Chapter	o	Technology Integration

				○ Modeling/Model-Eliciting Activities
42	Schindler, Joklitschke, Rott	2018	Book Chapter	○ Multiple Solution Tasks
43	Moraova, Novvotna, & Friedlander	2018	Book Chapter	○ Technology Integration (Hands on manipulatives)
44	Sheffield	2006	Book Chapter	○ Open-Ended Questions ○ Extendable Tasks
45	Ward et al.	2010	Journal Article	○ Abstractness of Mathematics
46	English	1997	Journal Article	○ Problem-Posing
47	English	1998	Journal Article	○ Problem-Posing
48	English	2003	Book Chapter	○ Problem-Posing
49	Leung, Silver	1997	Journal Article	○ Problem-Posing
50	Haylock	1987	Journal Article	○ Problem-Solving
51	Leikin	2009	Book Chapter	○ Multiple Solution Tasks
52	Sheffield	2009	Book Chapter	○ Open-Ended Questions ○ Problem-Posing
53	Voica, Singer	2013	Journal Article	○ Problem-Posing
54	Gilat, Amit	2014	Journal Article	○ Modeling/Model-Eliciting Activities
55	Singer, Voica	2015	Book Chapter	○ Problem-Posing
56	Fleith	2000	Journal Article	- Mistakes Free - Collaboration/Share Mathematical Ideas - Informal Language
57	Shriki	2008	Conference Proceedings	- Mistakes Free - Collaboration/Share Mathematical Ideas - Informal Language
58	Sriraman	2009	Journal Article	- Mistakes Free - Collaboration/Share Mathematical Ideas

Problem-solving

A reasonable number of studies (n=14) suggested problem-solving as an effective intervention that can help students develop creative abilities in mathematics (e.g., Albert & Kim, 2013; Haylock, 1997; Singer, 2012; Sriraman, 2005). Problem solving has been defined as “engaging in a task for which the solution is not known in advance” (National Council of Teacher of Mathematics [NCTM], 2000, p. 52). Engaging in mathematical tasks can be, for example, solving a contextual or non-contextual problem, proving a mathematical theorem or fact, and writing an equivalent expression of an equation. While engaging with such problem-solving tasks, students are expected to both build mathematical knowledge and create various solution strategies by mathematical reasoning and comprehending the interconnectedness of mathematical ideas (NCTM, 2000). Albert and Kim (2013) noted that students can further develop their mathematical creativity when they engage with problem-solving process that they apply diverse mathematical approaches to generate non-routine solutions (Albert & Kim, 2013). A creative problem-solving process requires students to think about existing mathematical rules and procedures so that they can follow non-routine solution process to generate original insights (Pehkonen, 1997).

Researchers not only stated the strong relationship between problem-solving and mathematical creativity (e.g., Yuan & Sriraman, 2011), but they also noted that problem-solving skill was one of the best indicators of mathematical creativity (Pehkonen, 1997; Silver, 1997). For instance, Silver (1997) proposed that problem-solving can be used as a tool to measure the creative abilities of students in mathematics by adopting the commonly used indicators of general creativity to mathematics as fluency (the number of mathematical solution ideas for a given problem), flexibility (the range of mathematical ideas for a given problem), and novelty (the uniqueness of mathematical ideas compared to the ideas of others for a given problem). The reason why problem solving was suggested both as a mean of mathematical creativity and as a mean of intervention for developing the mathematical creativity of students is because problem-solving requires students to employ their divergent and convergent thinking together to originate creative mathematical approaches. While convergent thinking enables students to organize and apply their previous mathematical knowledge and procedures in new mathematical problem-solving situations, divergent thinking enables them to think non-routine ways of solution methods (Carreira & Amaral, 2018).

For students to employ both their divergent and convergent thinking while solving mathematical problems, they should be provided challenging problem-solving tasks rather than a problem solely requires a computational procedure and rote memorization. For example, Vale, Pimental, Cabrita, Barbosa, and Fonseca (2012) found that students who engaged with challenging pattern related problem-solving tasks developed their creative abilities in mathematics. Likewise, Novita and Putra (2016) conducted a study by implementing challenging problems from PISA international test to mathematics classrooms. They concluded that engaging with challenging mathematical problems encouraged students to think creatively by provoking their curiosity in mathematics. Saragih and Habeahan (2014) conducted a quasi-experimental study to compare the mathematical creativity of two groups of students by means of a problem-based learning environment and conventional classroom environment. While students in the conventional classroom were taught via the traditional way of mathematics instruction, students who received the problem-based learning intervention were actively engaging with mathematical problems. The results of this study revealed that students who received problem-based learning intervention increased their problem-solving skills and mathematical creativity more than students who received conventional instruction. The results also demonstrated that students who were engaged with challenging mathematical problem-solving tasks used more variety of solution methods compared to students who were in traditional classroom (Saragih & Habeahan, 2014). Overall, problem-based focused learning environment in which students actively engage with challenging mathematical problems was found beneficial for developing the mathematical creativity of students.

Problem-posing/writing Proofs, Redefining

Problem-posing was another discipline-specific instructional practice that several research findings presented in this systematics review (n=22) suggested to develop the creative acts of students in mathematics. Problem-posing refers to the generation of mathematical problems or the reformulation of given problems (Silver, 1994). Problem-posing should be considered along with a problem-solving process rather than a separate practice that teachers can implement in mathematics instruction before, during, or after the problem-solving process (Silver, 1994). Problem-posing include three classifications as structured, semi-structured, and free (Stoyanova & Ellerton, 1996). While structured problem-posing activity requires students to generate mathematical problems according to a very specific scenario, semi-structured problem posing requires students to generate problems by completing an open scenario and free problem-posing urges students to freely originate problems for a given naturalistic scenario.

Although problem-posing has been considered a necessary skill to represent creative actions in mathematics since the early 20th century (Einstein & Infeld, 1938), it “has largely remained outside the vision and interest of mathematics education community” (Singer, Ellerton, & Cai, 2013, p. 2). However, the emphasis on problem-posing has accelerated as most studies that have investigated the effects of problem-posing on the mathematical creativity of students in this review were conducted on or after 2010. One reason why scholars have recently paid attention to problem-posing is because of its potential effects on developing the creative abilities of students in mathematics (Singer, Ellerton, & Cai, 2013; Van Harpen & Sriraman, 2013). “The act of finding and formulating a problem is a key aspect of creative thinking and creative performance in many fields, an act is distinct and perhaps more important than problem solving” (Jay & Perkins, 1997, p. 257). English (1997) also stated that problem posing was a vital practice for increasing the divergent thinking capacities of students in mathematics because problem posing enables students to look beyond the surface level of mathematical content. Deepening mathematical understanding requires mathematical reasoning and reflection, and these can be enhanced through problem-posing activities (Cunningham, 2004). The mathematical curiosity and enthusiasm of students appear when they are given opportunities to design and answer their own mathematical problems (Mann, 2006), and this process encourages students to appreciate the beauty of mathematics rather than seeing mathematics as a set of memorized rules and procedures.

Researchers not only suggested using problem-posing as a means of mathematical intervention to foster the mathematical creativity of students, but they also suggested using problem-posing as an indicator to measure the mathematical creativity of students (Balka, 1974; Kontorovich, Koichu, Leikin, & Berman, 2011; Jensen, 1973; Silver, 1997). For example, Singer, Pelczer, and Voica (2012) found that problem-posing as an inquiry-based instructional technique fostered the mathematical creativity of students and noted that having an ability to pose abstract mathematical questions was a key indicator of the creative abilities of students in mathematics. Similarly, Silver (1977) suggested that an integrating problem posing as a type of inquiry instruction can develop students’ creative abilities in mathematics and proposed a problem-posing model to measure students’ mathematical creativity. All in all, the studies presented in this systematic review noted that teachers can increase the mathematical creativity of students by integrating problem posing as an inquiry-based instructional model into their mathematics classrooms because problem-posing process offers ample opportunities for students to write various problems (promoting fluency), discover and adopt new mathematical problems by leaving the commonly used ones (encouraging divergent thinking or flexibility), and create a problem that is rare (advancing novelty) (Silver, 1977; Kandemir & Gul, 2007).

Open-ended Problems

Sixteen studies presented in this systematic review suggested an open-ended approach as an intervention that has the potential to develop the creative abilities of students in mathematics. Open-ended problems are defined as incomplete problems that do not specify clearly what the questions ask for, therefore allowing multiple interpretations for possible solutions (Becker & Shimada,1997). Kwon, Park, and Park (2006) defined open-ended problems as an instructional "strategy that aims to produce creative mathematics activities that stimulate the students; curiosity and cooperation in the course of tackling problems" (p. 52). Both definitions of open-ended problems (Becker & Shimada, 1997 & Kwon, Park, & park, 2006) emphasized that the mathematical problems that students engage with should not be restricted to a single method of solution within a single correct answer, but the mathematical problems should provide opportunities for students to explore various mathematical forms, representations, and strategies (Shriki, 2008).

Unfortunately, Sriraman (2005) noted that most school curricula do not apply an open-ended approach, which prevents students from exploring their creative abilities in mathematics. The mathematical practices of formal school curriculum mostly require students to develop their convergent thinking abilities in mathematics (Munandar, 2014), but developing the divergent thinking of students was mostly disregarded. Ignoring activities such as open-ended problem and problem-posing put obstacles for students in developing their mathematical creativity (Yuniarti, Kusumah, Suryadi, & Kartasasmita, 2017).

The creative abilities of students in mathematics can be fostered through open-ended problems that are related to real-life examples (Kandemir & Gur, 2007). Engaging with daily life related open-ended problems allows students to freely apply their imaginations in mathematics so that they can find novel mathematical ideas (Shriki, 2008). Open-ended problems do not only create opportunities for students to increase their cognition, but also establish a learning environment that individuals can hear the mathematical ideas, justification, and reasoning of others (Hiebert et al., 2000). This environment has potential to promote the mathematical creativity of students by exposing them to diverse mathematical ideas and perspectives. Integrating open-ended problems into mathematics classrooms enables students to find opportunities to express their cognitive and procedural understanding of mathematics (Mann, 2006). This might be also very helpful for teachers to understand the convergent and divergent thinking abilities of their students in mathematics to identify the needs of each student for developing their creative abilities in mathematics (Kandemir & Gur, 2007). In short, an open-ended approach promotes the mathematical creativity of students by allowing them to apply and integrate three indicators of mathematical creativity, namely, fluency, flexibility, and novelty to their mathematical thought process (Bahar & Maker, 2011; Silver, 1997).

Multiple Solution Tasks & Multiple Correct Answers

Multiple solution tasks or multiple correct answers (n=10) was one of the other suggested instructional strategies that emerged from the studies presented in this systematic review. Multiple solution tasks refer to tasks that can be solved in various ways (Leikin 2009; Levay-Waynberg & Leikin, 2012). Similar to problem-posing and problem-solving tasks that have been used to measure the mathematical creativity of students, researchers have also adopted Guilford's and Torrance's general creativity to mathematics by measuring the fluency, flexibility, and originality of students (Leikin & Lev, 2013; Kattou, Kontoyianni, Pitta-Pantazi, & Christou, 2013) along with multiple solution tasks. For example, Leikin and Lev (2013) found that students who were mathematically talented achieved higher scores of fluency, flexibility, and originality on multiple-solution tasks than students who were proficient and regular mathematics students. They concluded that tests requiring multiple solutions are very effective in measuring the creative abilities of students in mathematics.

Multiple solution tasks and/or multiple correct answer was suggested not only for measuring the mathematical creativity of students, but also for an instructional tool to foster the mathematical creativity of students (Livne, Livne, & Wight, 2008; Silver, 1997; Tsamir, Tirosh, Tabach, & Levenson, 2010). Applying various solution methods fluently is one of the important parameters of creative thinking in mathematics (Leikin, Lev, 2007; Silver, 1997). Engaging students with problems that can be solved through multiple ways and allow for multiple correct answers is considered an effective instructional practice to increase the mathematical creativity of students (Tsamir et al., 2010). Livne et al. (2008) also found that students who practiced with multiple solution tasks demonstrated higher mathematics achievement and more creative solutions than students who did not practice. Results from the studies presented in this review in general suggested that acquiring the habit of mind of searching for more than one method for a solution with more than one possible outcome should be employed in mathematics instruction to develop the creative potential of students in mathematics.

Mathematical Modeling/Model Eliciting Activities

Mathematical modeling or model-eliciting activities (n=6) is another instructional strategy that emerged from the studies presented in this review. Mathematical modeling is a process of creating models through choosing and selecting the appropriate mathematics to investigate, understand, and improve mathematical ideas (The Common Core State Standards, 2010). Model-eliciting activities were defined as tasks that require students to create a model to solve open, messy, and complex problems in a real-world context (Amit & Gilat, 2012; Chamberlin & Moon, 2005; Wessels, 2014). The open-ended, complex, and messy tasks offer ample opportunities for students to develop mathematical models and elicit their creative thinking and actions in mathematics (Chamberlin & Moon, 2015).

English (2003) noted that two main reasons existed for why mathematical modeling should be implemented in mathematics instruction: 1) mathematical modeling activities offer meaningful mathematics learning by enabling students to use their prior mathematical knowledge to construct new mathematical knowledge, and 2) modelgn activities help teachers understand the mathematical thinking of their students during mathematical problem-solving.

Several scholars have studied model-eliciting activities. For example, Gilat and Amit (2014) conducted a case study to observe how student experiences with model-eliciting activities changed their flexibility, combinations, and analogy in mathematics. After students completed a model-eliciting task intervention, an interview was conducted. One student shared her feelings by saying "I didn't know how to apply to the task; I had to think in a different way, to think more real thinking, there was no single right solution and it made me think about other solutions, which is the best one, and not to think in a rigid way" (Gilat & Amit, 2014, p. 57). Through investigating data from student interviews and model-eliciting tasks, Gilat and Amit (2014) concluded that model-eliciting activities are helpful practices that "could establish the foundations for creative process development methodology" (p. 57). Wessels (2014) also noted that model-eliciting activities increased the divergent thinking of students, communication skills, multiple representations skills, cognitive flexibility, and creativity in mathematics. In addition to these, modeling activities promote an appreciation of mathematics among students because these activities make the mathematics learning of students more meaningful by enabling them to apply mathematics in a real-life context (Chamberlin & Moon, 2005) and allowing them to use their previous knowledge to create new mathematical knowledge. Students can increase their convergent and divergent thinking abilities in mathematics when they have chances to create their own strategies to solve mathematical problems through mathematical modeling (Manuel, 2009) because these tasks support the ability of students to create, execute, evaluate, and refine various solution methods of given problems. In the light of the findings coming from the studies reported in the present systematic review, the conclusion can be made that mathematical modeling tasks promotes the fluency, flexibility, and originality of students (Coxbill, Chamberlin, & Weatherford, 2013).

Visualization through Technology Integration, Hands on materials, and Manipulatives

Integrating technology into mathematics classroom was emerged as another suggested instructional practice (n=5) in this systematic review. The studies suggested usage of hands-on materials or manipulatives (Siew & Chong, 2014; Moraova, Novvotna, & Friedlander, 2018), graphic calculators (Idris & Nor, 2009), and computers to foster the mathematical creativity of students (Pehkonen, 1997; Moraova, Novvotna, & Friedlander, 2018). Integrating technology (e.g., calculators, computers) into mathematics classrooms offers opportunities for students to further develop their mathematical creativity through promoting student-teacher interactions and creating a student-centered learning environment (Idris & Nor, 2000). Using manipulatives or hands-on materials was also found to be an effective practice that nurtures the creative abilities of students in mathematics. For example, Siew and Chong (2014) conducted a quasi-experimental study to observe if there were any differences between two groups of elementary school students on their creative abilities in mathematics. While one group engaged in tangram activities, the other group continued traditional lecture-based instruction. The results revealed a statistically significantly difference between the mathematical creativity of students favoring the group engaged with tangram activities. Siew and Chong (2014) also noted that students felt integrating manipulatives into mathematical classroom provided them with opportunities to think creatively. In general, the studies suggested technology integration into mathematic classrooms (Idris & Nor, 2000; Moraova, Novvotna, & Friedlander, 2018; Pehkonen, 1997; Siew & Chong, 2014) advocated using manipulatives, graphic calculators, and computers to develop the divergent thinking abilities, critical thinking, and problem-solving skills of students. In the 21st century, students should fluently use these technological tools not only in the mathematics classroom but in their daily lives to tackle the complex and messy problems of technology driven society (Idris & Nor, 2009).

Extendable Tasks & Emphasizing Connectedness and Abstractness of Mathematics

Another suggestion (n=2) was to emphasize the importance of conceptual understanding of mathematics (Mann, 2006) and to emphasize the abstractness of mathematics instead of computation (Ward et al., 2010). Students should be given opportunities to understand that mathematics does not solely comprise memorizing a set of mathematical procedures and rules. To achieve this, a teacher should encourage students to recognize the essence of mathematical problems to generate creative mathematical ideas rather than simply focusing on computation (Mann, 2006). Research has noted that students appreciate the usefulness and beauty of mathematics when their mathematics instruction is aimed at increasing conceptual understanding by emphasizing the connectedness and the abstractness of mathematics instead of computation (Ward et al., 2010). In order for teachers to communicate the importance of abstractness of mathematics to their students, they should select activities that promote abstract thinking. Another suggestion was adopting activities that can be extended (Sheffield, 2009). The mathematical creativity of students can be promoted through activities that can be extended further for additional inquiries. Engaging with an extendable mathematical task offers students opportunities to ask more questions and encourage them to comprehend the interconnections of their existing mathematical knowledge that they have applied to solve the initial steps of a task with the new ones that they need to utilize to solve the extended part (Sheffield, 2009).

General Instructional Practices

A second theme that emerged from the studies in this systematic review was general instructional practices (n=8) that were suggested to increase the creative potential of students in mathematics. One of the most common suggestions was to promote the idea that mistakes are acceptable while trying to solve a problem (Fleith, 2000; Nadjafikhah, Yaftian, Bakhshalizadeh, 2012; Shriki, 2008; Sriraman, 2009). Allowing students to make mistakes can lead them to find uncommon methods of solutions that they can promote their fluency, flexibility, and originality in mathematics. Enabling students to pursue unique ways of solutions without having a fear of making mistakes requires time. So, another important suggestion for fostering the creative abilities of students during mathematics instruction was offering a longer duration of time for engaging with engaging mathematical problems (Mann, 2006). Students need ample time to perform creative acts in mathematics because creativity requires students to deeply think, analyze several methods, and refine their solutions (Wessels, 2014).

Researchers also suggested that establishing a collaborative classroom environment rather than a competitive one was also one of the keys to develop the creative abilities of students in mathematics (Fleith, 2000; Nadjafikhah, Yaftian, Bakhshalizadeh, 2012; Shriki, 2008; Sriraman, 2009). For example, Sriraman (2009) suggested that teachers should encourage students to take intellectual risks and share their mathematical ideas with others. When students share their mathematical point of views with each other, their mathematical imagination becomes more diverse, and this, in turn, may increase their cognitive flexibility in problem solving.

Fleith (2000) and Shriki (2008) noted that teachers should provide a secure atmosphere so that each student can have a voice and their mathematical ideas are respected. Students should be encouraged to use their own words and representations to share and communicate their mathematical ideas with others rather than solely repeating memorized notations, facts, or graphs. This will enable students to create connections between their mathematical learning and their daily lives. All of these instructional practices (make mistakes, more time, share ideas, take risks, and informal language) suggested by the studies (e.g., Fleith, 2000; Mann, 2006; Nadjafikhah, Yaftian, Bakhshalizadeh, 2012; Shriki, 2008; Sriraman, 2009) presented in this review taken together can help teachers establish mathematics instruction that promotes the mathematical creativity of students.

Discussion

The review highlighted several instructional practices influencing the development of the creative abilities of students in mathematics. The common features of the suggested instructional practices seen to be promoting mathematical creativity were similar to those of inquiry-based learning (IBL) models in that students ask meaningful questions, investigate multiple solutions paths, create ideas by gathering and combining a variety of sources, discuss generated ideas with others, and reflect their own learning (Bruce, 2011). The IBL was first developed during the discover learning movement (Bruner, 1961) as an alternative instructional approach to traditional instruction in which students were instructed to learn by rote memorization. The studies presented in this review suggested instructional practices very similar to IBL. For example, the suggested practices encourage students to pose their own mathematical problems, implement multiple solution tasks, create mathematical modeling through connection several mathematical ideas, and extend the mathematical tasks by further questioning.

Likewise, an important common feature of the suggested instructional practices that promote the mathematical creativity of students is that these practices are very similar to the instructional practices of IBL model. For example, IBL requires a student-centered learning environment in which students are expected to work both individually and cooperatively to determine a loosely defined outcome through optional solution methods. The instructional practices suggested by the studies in this review (e.g., students' creative abilities are fostered through asking questions, taking risks to share their mathematical ideas, collaborating with others to hear diverse mathematical perspectives) are indeed the core features of the IBL model.

Furthermore, research suggests that the mathematical creativity of students can be developed further when they engage in problem-raising opportunities with sufficient time to ask questions, make investigations, connect prior mathematical knowledge, and relate their real-life examples are similar to the learning principles of IBL that students construct new knowledge through their prior experiences and knowledge. In the IBL model, students are expected to make judgements and observations regarding a scientific phenomenon by employing their senses. This is also similar to the suggestions that students should be provided an extensive amount of time and space to make their own mathematical investigations by observing, testing, and refining multiple solutions processes. In general, the conclusion can be made that the instructional practices suggested by the studies presented in this review have their roots from IBL model and can promote the mathematical creativity of students.

Implementing these instructional practices that share commonalities with the IBL model in mathematics classrooms are vital to increase the creative endeavors of students in the mathematics classroom. IBL was mostly implemented in science courses in which students engage in hands-on activities to solve authentic problems (Savery, 2006). However, this current review showed that students' mathematical creativity can also be promoted when teachers implement the suggested practices that similar to the features of IBL to mathematics classrooms.

Students may not increase their mathematical creative abilities if their teachers limit mathematics instruction to rule-based applications and do not invoke the abstractness, beauty, and essence of mathematics (Mann, 2006). Unfortunately, many teachers emphasize computation instead of the abstractness of mathematics (Mann, 2006). Boaler and Dweck (2016) stated that, according to students, mathematics is a subject of performing calculations by following well-defined procedures along with a set of rules. Conversely, mathematicians have defined mathematics as a field of patterns that require aesthetic and creative performance (Devlin, 1997). The reason why the definitions of students and mathematics professional conflict is because most students possess misconceptions about the subject due to the experiences in their mathematics courses. Most mathematics instruction is designed in such a way that students are expected to find the right answer by applying a set of rules and procedures as quickly as they can (Boaler & Dweck, 2016). However, mathematics is not a merely subject of being right or wrong, fast or slow, or the ability to memorize rules or procedures. The instructional practices presented in this study suggest that students find opportunities to develop their abilities when their teachers create an environment in which mistakes are acceptable while solving or posing mathematical problems (Fleith, 2000; Nadjafikhah, Yaftian, Bakhshalizadeh, 2012; Shriki, 2008; Sriraman, 2009). Mathematics instructions should emphasize students' efforts rather than their answers. This recommendation is similar to a feature of IBL in which students do not have to come up with a final product at the end of their investigations, but their efforts in observing a scientific phenomenon, asking questions, creating a hypothesis, and testing their constructed hypothesis are essential. The mathematical effort of students should also not be considered in terms of how quickly they can calculate and come up with correct numbers. Bolaer and Dweck (2016) stated:

> The powerful thinkers in today's world are not those who can calculate fast, as used to be true; fast calculations are now fully automated, routine, and uninspiring. The powerful thinkers are those who make connections, think logically, and use space, data, and numbers creatively (p. 31).

In general, instructional practices suggested by the studies presented in this review encourage teachers to design their mathematics instructions in a way that fosters the ability of students to make mathematical connections, think logically, and use resources as effectively as possible so that students can reach their creative potential in mathematics. It is possible to think which strategy is the best to increase the mathematical creative endeavors of students. However, most of the suggested practices are not mutually exclusive from one another, and they can support and complement each other to increase the likelihood of increasing the creative acts of students during mathematics instruction. The important question is how meaningfully teachers can combine a mixed of various of these suggested practices into mathematics classrooms through well-defined outcomes with ill-defined mathematical tasks. For example, Silver (1994) suggested that problem-posing should be considered along with problem-solving practice rather than as a separate and isolated classroom practice. Teachers can implement problem-posing practice before or after problem-solving activities based on the goal of instruction. As can be seen in Figure 2, problem-posing and -solving can be considered two main practices that teachers should prepare these two practices along with other suggested practices (e.g., open-ended, modeling, extendable). For example, rather than engaging students with the following problem, "Ali is 21 years younger than his father and his father is 19 years younger than Ali's grandfather. If the sum of their ages is 119, how old Ali is now?", teachers can make this problem more open-middle (solving with multiple ways, but have one correct answer) by changing it as, "if the sum of three generations' ages (e.g., grandson, son, and granddad) in a family is 120, how old the grandson can be?" Doing this will enable students to think their ages related to their dad and granddad and they may come up 20 years differences from one to next generation. It is not only vital to ensure that the problem is related to students own life, but it is also crucial that they can come up with multiple paths since the little changes on the initial problem make it more open. After solving that kind of problem, teachers can ask students to extend the problem or pose similar ones to have a meaningful combination of the suggested practices.

As suggested, it is possible for teachers to integrate various combinations of the suggested instructional practices within one mathematical task. For example, it is possible to implement an open-ended task that can be solved through several methods, be extendable for further investigations, and emphasize the abstractness of mathematics. Implementing various meaningful combination of these practices in mathematics classroom may change the general view of students about mathematics from a field of performing calculations by applying a memorized set of procedures and rules to a field of recognizing patterns through logical, beautiful, aesthetic, and artistic performance. When students recognize the beauty of mathematics through engaging in activities that emphasize the abstractness of mathematics instead of computations, they will appreciate the field and put their efforts into solve mathematical problems creatively. Implementing the suggested practices in this research to foster the mathematical creativity of students into mathematics classrooms will provide students with opportunities to comprehend that "mathematics is not about numbers, but it is life. It is about the world in which we live. It is about ideas. And far from being dull and sterile as it is so often portrayed, it is full of creativity" (Devlin, 2000, p. 76). Lastly, the reported discipline-specific and general instructional practices (e.g., risk taking, mistakes are acceptable, multiple ways of solutions, open-ended tasks) can not only promote students' creativity and equitable thinking in mathematics classrooms, but it can also create more equal educational opportunities to minority students when creativity is included in admissions to college, graduate schools, and gifted education programs.

Implications/Recommendations/Limitations

Revealing these instructional practices collectively through applying a systematic review can help teachers integrate these practices into their mathematics classrooms to foster their students' creative acts in mathematics. Also, this study can be helpful for mathematics education researchers to construct an instrument that measures the awareness and perceptions of teachers of the suggested practices that can foster the mathematical creativity of students. Future research should be conducted to understand if pre-service and in-service teachers are aware of these practices. This systematics review is limited to the field of mathematics, but further research could be conducted to reveal the instructional practices that influence the creativity of students in other STEM fields and this help to decide if the suggested practices can be applicable to other STEM-related disciplines.

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