International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

A Study on the use of Problem-Posing Approach and Pre-Service Elementary Teacher's Creativity, Anxiety and Beliefs to Teach Mathematics: A Systematic Review

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Abstract: ***This quantitative research investigated the perception of mathematical creativity and if there is a significant relationship to the epistemological mathematics beliefs of the nature and anxiety of mathematics. The study used three instruments to assess the research participants. The instruments included general assessment criteria, questionnaire on mathematics beliefs and mathematical creative ability. This empirical study used counterbalance study design with random sampling of elementary education teachers to help in answering the significant research questions. Repeated measures were taken to evaluate if there exists a significant relationship between variables. The study findings indicated that anxiety and beliefs correlated with mathematical creativity that employed both the pre-test and post-test mechanisms. According to this research study's results, mathematical anxiety and beliefs had a significant impact on divergent thoughts, alternative algorithms, problem posing and invented strategies.***

1. Introduction

1.1Background Information

The word "problem posing" has grabbed a considerable attention by recent mathematics researchers in which they report that problem posing is one of the effective and efficient strategies used by elementary education teachers for teaching and learning mathematics [1]. The term 'problem' has a relative definition in which its meaning relies on an individual's perspective [2]. [7]Defines the term problem in mathematical terms in which they feel that the term encompasses all situations where solutions are needed and where a way to arrive at the solution is known. On the other hand, a problem is any engaging question in which the learners have only necessary procedural and factual knowledge but no readily accessible set of mathematical steps to arrive at a solution. Mathematical problems are often mistaken for exercises but there is a difference; an exercise aims at confirming whether the learner understood the recently taught symbol or mathematical vocabulary.

A new consensus has been developed in which the researchers of mathematics education feel that problem posing entails creating new problems and recreating given problems. Another scholar sees problem posing as the idea in which learners create personal explanations of solid situations and convert such situations to mathematical problems and this process creates educational experience [3]. Inarguably, teachers play a significant role in problem posing process as they make a difference in the learners' experience. Through teachers, the learners are able to not only create but also explore different mathematical relationships in the classroom. According to Kapur [4], learners are inspired and influenced by teachers into exploring curiosities and new wonders about mathematical universe. On the contrary, teachers can be viewed as overwhelming liabilities following all their potential assets. For instance, the elementary educators with mathematics anxiety are likely to produce learners who also have mathematics anxiety, some scholars mentions that teacher's beliefs and attitudes are directly linked to learners' beliefs and attitudes towards mathematics [5]. Attitude and beliefs influence the ability of the learner to decide on the choice of prospective occupation and even when making decisions on pursuing advanced work in mathematics.

According to a research done by Sari and Surya [6], the elementary teachers have higher anxiety in mathematics with its origins being linked to traditional or formal pedagogical practices. These researchers also determined that there is a significant negative relationship between the teacher's beliefs in his/her skills and their ability to become a competent and effective mathematics teacher. Elementary teachers play a significant role in impacting the ability of learners to be creative and solve mathematical problems creatively. It is argued that traditional techniques of teaching elementary mathematics emphasized only on the formal content at the outlay of making the learners see the investigative and creative nature of mathematics [8]. For this reason, it is evident that elementary pre-service educators have a great potential to impact young children towards attitude and their beliefs in mathematics.

1.2 Problem Statement

Extant literature review indicated that several mathematical techniques and instruments have been formulated to help in testing the ability of the students to be creative in mathematics and solve mathematical problems accordingly. However, these testing methods, according to [6], have proven to be time consuming and this has undermined the identification and development of young mathematics talents. Beliefs and attitudes are the key determinants in the process of a learner to become creative and solve mathematics problems. Particularly, attitudes and beliefs are agent catalysts of how learners and elementary teachers will act and react on a given mathematics situation or problem.

Based on this observation, it is correct to conclude that if beliefs and attitudes predict negativity then mathematical creativity will be lower. The current mathematical instruments lack the element of including the teacher's and the elementary learners' perspective, attitude and belief towards given problems. It is significant to understand the importance of attitudes and beliefs and their effects on classroom practices. This research attempts to investigate the incorporation of problem posing alongside the beliefs, attitudes and perspectives of a teacher in teaching mathematics effectively.

1.3 Purpose of the Study

The extant literature review has shown that many studies in mathematics have been done concerning the use of problem posing approach as an instructional technique to determine the learners' performance in mathematics. The evidence from different research studies has shown improvements in mathematics through the incorporation of problem solving, attitudes and beliefs in teaching mathematics. The researcher conducted a study with pre-service elementary teachers from different locations in Mumbai, India. The main aim of this study was to investigate how intentional experience to problem posing and mathematical creativity affects mathematical anxiety. The research aims to investigate if the variables; beliefs, creativity and anxiety predict each other. The study results to prove if these variables correlate and in the event a relationship exist, that would inform the researcher that the beliefs of mathematics educators and teachers corresponds to mathematical creativity and anxiety. The study will also examine if students benefit more when they are exposed to problem posing as an instructional method.

1.4 Research Questions

The general purpose of this study was to examine elementary pre-service teacher's mathematical beliefs towards problem posing. In more details, this research attempted to respond to the following research questions:
RQ 1: What are the elementary mathematics educator's problem posing approaches and beliefs towards teaching of elementary mathematics?
RQ 2: Is there any significant relationship between pre-service elementary teacher's mathematical anxiety and mathematical creativity?
RQ 3: Is there any significantrelationships between pre-service elementary teacher's beliefs and their mathematical creativity?

This mixed study design investigated the idea of creativity in mathematics and its source beliefs of the nature of mathematics. Counterbalance design with random sampling was adopted to determine if there existed a significant difference in the research participants who were provided with problem posing instructional design.

1.5 Significance of the Study

Problem posing forms a significant instructional method when the learners sense two things; that the educators regard the problem as a significant activity and that the teacher engages them actively in solving a problem in daily mathematical instructions [6]. This research proved that teacher's preferences and beliefs on how to teach mathematics play an important role in how different educators and teachers teach mathematics in classroom. This study has also revealed that it is vitally significant to have a clear understanding of a mathematical problem before engaging the learners. Additionally, the research revealed that a proper understanding of a problem relies on the teacher's beliefs, anxiety, confidence and creativity. Although many studies have examined factor relating to problem solving and the learner's abilities to solve different problems, little research has been conducted to report how different pre-service elementary teachers view problem solving. Furthermore, different studies in India [1] have revealed that there are inadequate research activities in the training institutions, and this is a major issue in producing competent educators who are able to help learners. This study will provide an insight into how different elementary pre-service teachers in India view problem posing in mathematics education.

2. Literature Review

2.1 Problem Posing

Different researchers view the term 'problem posing' in almost similar but different ways. For instance, [1] and [9] define the term as an instructional method which puts emphasis on critical thinking for liberation purpose. According to [13], problem posing is an approach in mathematical methodologies in which an instructor make deposits of knowledge and information into the empty accounts of students to diversify the subject matter and compel students to use the gained information and knowledge to develop an acute understanding of imbalanced conditions and personal experience. In this mathematical pedagogy, a teacher postures knowledge in any way as a problem for mutual inquiry. This instructional technique does not suggest that learners have nothing to learn from pre-existing but rather, it makes learners and instructors to concern themselves with how syllabi and texts are organized with some underlying assumptions of a discipline or a course and questioning the perspectives and sources excluded or included from the domain of the course.

2.2 Creativity

According to [12]there is no constant meaning of the word creativity but rather, different researchers and scholars have defined this term in innumerable ways while considering various themes. Such themes include Societal and Individual, Product and Process, Utility and Originality, Orthodox and Radical Novelty, Creativity and Problem Solving, and Fostering of Creativity.

Societal and Individual

Some researchers examined the term creativity through dissecting it into societal and individual creativity [11], [12] and [15]. Societal creativity is creating and solving problems for masses whereas individual creativity solving problems in different areas individually or at a personal level [7].

Product and Process

Scholars classify creativity as product or process. For instance, Leikin and Sriraman use the terms 'creative production' and 'creative potential' to differentiate between tangential products and mental processes [14]. These scholars argue that product and process creativity use different pedagogical approaches to think critically about a concept or an idea as well as a new analysis of a problem or a situation to understand it better. It also entails the agglomeration of numerous thought processes such creating analogies to arrive at a destined solution.

Utility and Originality

Peraargues in his amalgamation that the word creativity contains novelty or originality and these forms two useful characteristics of defining this term [19]. On the other hand, Ayllon, Gomez and Ballesta-Claver disputes that novelty is the main distinctive characteristic that articulates the objective criteria of identifying creative products [3]. The originality of a mathematical product or concept is identified by its appropriateness, usefulness or social value to a person. Utility and originality in creativity act as counterbalancing weights in which too much of one of it will interrupt the inventive balance. Sriraman and Dickman argue that a response or a product cannot be different just to achieve difference; that response must be valuable, accurate, and expressive of a meaning and appropriate[26]. Originality precedes utility in which

Orthodox and Radical Novelty

Sriraman argues that creativity is regulated in different disciplines [27]. He points out that some disciplines such as mathematics accept higher degree of creativity than other disciplines. For example, the degree of creativity needed to find a solution for a mathematical function such as '$u(x, y) = xy-x+y$,' is far higher than that needed to find a solution for separating a mixture of iron filings and flour. Pera support the idea of orthodoxy by arguing that a product or an activity must be novel with some slight departure from the prevailing concept [19]. Sriraman and Dickman add that any concept or idea that comes as result of creativity must not only be novel but also be connected to theory [26].

Problem Solving and Creativity

Problem solving is inarguably creative in nature. Pera describes the process of problem solving as the capacity of a learner to find solutions to given problems in a particular domain using a concept learn in way that is ultimately acceptable [19]. It requires that an individual have a detailed knowledge of a theory or a concept and later apply it to a challenging situation or a problem and come up with a working solution ultimately.

Creativity Fostering

There ways to enhance creativity. Such ways include building basic skills, encouraging the acquisition of specific knowledge, establishing purpose and intention, stimulating and rewarding exploration and curiosity, intrinsically building motivation, encouraging willfulness and confidence to handle a particular risk, providing opportunities for choice and discovering metacognitive skills. For classroom teachers, Luria, Sriraman and Kaufman offer solutions for fostering creativity [17]. They suggested that some of strategies that can be used include serving as role model in creativity, encouraging learners to question assumptions, rewarding creative concepts and ideas, encouraging learners to be tolerant of ambiguity and nurturing and recognizing creative thinkers.

Mathematical Creativity

Similar to creativity, there is no relative definition for mathematical creativity. Different researchers give different views depending on how they observe and examine the term. For example, Haavold define mathematical creativity as the ability to give variety of dissimilar and applicable responses to mathematical situations whether in written form, chart or graphic form [10]. Correspondingly, Peraviews mathematical creativity as strategies and algorithms or applicable alternative approach and techniques to standard problems [19]. Sengul and Katrancidefined mathematical creativity as finding ways to overcome divergent products and fixations [21]. On the other hand, Sari and Surya think that mathematical creativity manifest in five different ways: (a) generating formulas to invent proofs, (b) applying problem posing, (c) applying alternative approaches and methods, (d) creating unique methodologies to solve different mathematical problems, and (e), applying a concept learned in theory to real mathematical problem [20].

Pera has also mentioned that mathematical creativity can be diverted into a product or a process, that is, a process of thinking in which the product is manifested in flexibility, originality and fluency [19]. Mann et al. define flexibility, originality and fluency collectively as follows: flexibility means various answers; originality means methods, approaches, questions and answers and fluency means the total correct solutions and methods [18]. There are several techniques to foster mathematics creativity in classroom. According to Singer, Ellerton and Cai, a creative teacher is in front of producing learners who are creative in almost all spheres of mathematics [23]. The scholars believe that a teacher can foster mathematical creativity by posing problems, asking applicable questions, providing opportunities to making an exploration and observation and to encourage learners to have discussions.

Problem Posing and Teachers

The process of problem posing starts when the learners start to view themselves as knowledgeable persons by critically examining and writing the knowledge in a given field, course or discipline. The process also entails learners identifying relevant social contexts problems and aspects and later identifying plausible mechanisms to arrive at the required solution. According to Singer, and Voica, problem posing utilizes topical themes with various dialogues to create an action [22]. It also uses cases, entry frames and exploring complexities to take a collective action that can respond to a given problem collectively. Based on numerous research studies pertaining problem posing as a pedagogical approach in mathematics, this instructional method is capable of instilling problem-solving skills to learners. According to Vale and Barbosa problem posing forms a developmental tool for elementary learners as it offers a potential to extend what they know to what they do not understand so as to engage them in high order thinking and develop mathematical fluency [30]. Strom et al. believe that learners must have imaginative skills in order to creative an effective problem [28]. These imaginative skills can be developed systematically through the process of solving presented problems. Learners must think mathematically and creatively to reformulate and regenerate new mathematical problems.

Based on the research done by Junaedi et al., problem posing has resulted to positive outcomes on the learner's knowledge, the abilities for problem solving, disposition and creativity towards mathematics [12]. Similarly, Bazylevych, Guran and Zarichnyidiscovered that the teachers who applied problem posing mechanisms and the related activities positively contributed to a learner's mathematical knowledge [5]. These researchers applied adapted problem posing into two learning workshops on geometry and complex analysis. Their research results revealed that learners who were exposed to problem posing instructional method had a deeper understanding of geometry and complex analysis and the approach strengthened their interrelated ideas and concepts. Another empirical study done by Sung, Hwang and Chang investigated the impacts of problem posing activities on beliefs and attitudes of both teachers and learners about mathematical concepts and the related methodologies [29]. In this study, the researchers showed that when teachers and different instructors incorporated a problem posing mechanisms, their classrooms became more of student-centered than teacher-centered as learners were more involved in creating their own problems and solving them. Particularly, problem posing instructional design offered learners with an opportunity to own a problem they generated and share the solutions with their peers. Singer and Voica discovered that encouraging the learners to formulate ideas, share and critique them during mathematical activities, the learners were able to develop inquiry and disposition skills which in turn helped them to develop to effective problem posers [22].

Teacher's Mathematical Beliefs and Problem Posing

As stated by Song, beliefs refer to psychosomatically held principles, propositions and understandings about the world which are felt to be true [25]. Beliefs form personal values, assumptions and views that influence the decisions which a person makes throughout their lifetime. According to Sriraman, beliefs are the center of a person's action; hence, they explain a person's given behaviors [27]. Teachers rely on their beliefs and knowledge to understand, interpret and act on given concept. Beliefs have considerable effects on teacher's actions since it plays a significant role in how a particular teacher carries out a given instructional method and the way they present a concept. According to [19], a teacher's conception on what a mathematical concept, idea, or a problem is affects his or her ability to present that it and the manner in which he or she will present in. Teachers and different instructors possess beliefs towards their profession, how their teaching takes place, their subjects and how their students will learn.

Different research studies have been done to develop a better understanding of teacher's practices and all factors affecting their beliefs. For instance, a research done by Lester and Cai which tried to investigate factors that affect the beliefs of a teacher and how teaching should be done, the results showed that the climate of a classroom, the goals of a school, the availability of instructional facilities and materials, curriculum guides, colleagues and the policies of the school affected the beliefs of a teacher [16]. The researchers also determined that support from colleagues, teaching education programs, individual classroom practices and experience affects how a teacher will view a given subject matter. On the other hand, Song carried out a research study on both pre-service elementary teachers and secondary school teachers on how different courses in mathematical methods affect their knowledge and understanding of mathematics and their beliefs and attitudes towards different concepts [25]. The results revealed that mathematical knowledge gained in a given course affected teacher's beliefs and attitudes towards given concepts. The researchers concluded that if there should be a reform in mathematics discipline, the teachers ought to have an adequate comprehension and understanding of meaningful mathematical concepts and general content.

Teacher's Attitudes and Beliefs towards Mathematics and Problem Solving

Peris (2015) differentiated the attitudes and the beliefs of a teacher as problem centered and knowledge centered. The researcher also mentioned that all those teachers who viewed mathematics discipline as knowledge centered had a belief that mathematics is a compilation of hierarchical knowledge and that the idea of solving problems is a final process based on the knowledge acquired previously. On the other hand, the research also revealed that those teachers who viewed mathematics as problem centered had a belief that mathematics discipline comprises of hypothesis making, generalization, searching for newer problems and justification of these problems. Sriraman and Dickman distinguished mathematics teachers as individuals who believe that mathematics is static set ideas, procedures and concepts and the persons who understand that mathematics discipline is a mental process of constructing proofs, hypothesis and refutations to solve given situations and problems [26]. The same research concluded that learners have to master the conceptual skills before attempting to solve any given problem in which a teacher is in charge. The research determined that the conceptual skills and knowledge were the essential component of mathematics' curriculum.

The Impacts of Beliefs of a Mathematics Teacher on their Students and Classroom

Various research studies on the subject matter established that there was a significant relationship between the teacher's beliefs and practices and the mathematical learning outcomes of the students [21], [25] and [29]. The research evidence presented by Song illustrated that the student's performance had a significant relationship with attitudes and the beliefs of a teacher [25]. Strom argues that the ways in which a particular teacher or instructor presents a given concept or subject matter, the types of tasks they set, the methods used for assessments, criteria and teaching procedures determines the learner's achievements [28]. Following these observations and due to the fact that the knowledge, beliefs, decisions, attitudes and judgments of a teacher have a significant relationship with the beliefs, the performance and the attitudes of learners towards mathematics, it is essential to be aware of such beliefs towards classroom practices. The beliefs of a teacher have a significant effect on the attitudes of a learner on problem solving and about mathematics discipline in general. Based on the research done by Mann and Chamberlin the beliefs of instructors and mathematics teachers affected the attitude of students as they passively received information from helpless responses given by their teachers [18]. The teachers who believed in hard work, problem solving and better understanding of the key concepts in mathematics made their students to develop the same beliefs.

Mathematical Creativity, Mathematical Curiosity and Problem Posing

According to Leonard (2018), there seems to be a relationship and link between mathematical creativity, mathematical curiosity and problem posing. He suggested that mathematical curiosity is solicited by problem posing and that this mathematical curiosity provides a gateway to the mathematical creativity. Similarly, problem posing enhances mathematical creativity. Using the work of Chapman, problem posing can be defined by five steps of pose-and-probe rubric in which a learner or a teacher identifies a problem first, he or she then identify the attitudes of that particular problem, investigate the attributed questions and then relate his or her investigation to an original problem [8]. In some sense, problem posing advances a particular problem to n^{th} degree using nomenclature or common vernacular through the alteration of the initial assumptions or conditions of a problem.

Children are naturally curios and naturally learners in which they are not in unmitigated states but rather, they own some background information on how the world works which means that they are problem solvers. It is the responsibility of the teacher to make learning inherent so that children can develop curiosity and the zeal to learn. Curiosity makes the learner to not only know mathematics but also explore it. Problem posing appears to be a ground on which mathematical curiosity is solicited and its role in mathematics curriculum validated. According to Peris, problem posing offers the learners with more ability to reason and study mathematical problem solving [19]. As stated by Haavold, it promotes the learner's conceptual development, play a significant role comprehending a problem, allowing access to significant mathematics and promoting the student's creativity and curiosity [11].

Felmer, Pehkonen and Kipatrick argued that problem posing is a forgotten concept in mathematics yet it is a complement and a counterpart of problem solving [9]. Since metacognition is required in problem solving, the major aspect in this process is the reflection of what was done in a particular problem solving process. Based on the four approaches (understanding, planning, carrying out, and looking back) to problem solving suggested by Huang et al., problem posing gives the learners an opportunity to look back and reexamine a given concept while reflecting on related theories and ideas [11]. Posing permits the learners to reflect on a particular concept which in return helps them to explore the content of the problem, develop self-reflection, extend solutions and explore different ideas. According to Sari and Surya, problem posing does not only lead to curiosity but it does also set the stage for mathematical creativity. The researcher also argues that problem posing is naturally creative in itself and it is the interplay link connecting problem solving and mathematical creativity.

3. Methods

Research Design

In this study, the pre-service elementary teachers were pre-tested and post-tested during the fall semester of 2018 with four instruments. The researcher developed Mathematical Beliefs Questionnaire (MBQ) to assess the participants' mathematical beliefs. The researcher also used Felmer's, Pehkonen's and Kipatrick's instrument of Abbreviated Mathematics Anxiety Scale to measure the pre-service elementary teacher's anxiety on the nature of mathematics [9]. The researcher measured mathematical creativity and problem posing using Cai et al.'s General Assessment Criterial Tool (GACT) [7] and Chapman's [8] Creativity Abilities in Mathematics Tool (CAMT). Table 1 below shows these tools represented in a counterbalance design.

Table 1: Counterbalance Design

Pre Assessment			Post Assesment		
GROUP A Randomly	AMAS GACT AMAS MBQ	Treatment	GACT	No Treatment	AMAS GACT AMAS MBQ
GROUP B Randomly	AMAS GACT AMAS MBQ	No Treatment	GACT	Treatment	AMAS GACT AMAS MBQ

The researcher then formed two groups through assigning randomly the pre-service elementary teachers. A random number table was developed in which the research participants who were elementary pre-service teachers were assigned randomly either group A or group B. The first group, which was group A of the participants, received treatments such as intentional experience they have over problem posing, and invented and divergent thought strategies. Group B, which was the second group did not receive any treatment. The researcher then assessed the two groups using GACT. The treatment criterion was then switched so that group B receives treatment while Group A being assessed without any treatment. The two groups were then assessed for the second time using GACT tool.

Procedures

The researcher recruited the research participants from both elementary schools randomly in Mumbai, India and those who were still undertaking elementary pre-service mathematics courses in two colleges of education. These research participants exposed to general knowledge and the objectives of this empirical study in which the investigator recruited a third party individual to distribute and collect the consent documents from all participants who were willing to play a part in this research. The consent documents and forms were secured in locked cabinets to avoid access by unauthorized parties. The research participants were then requested to complete two surveys on mathematical anxiety and mathematical beliefs and the responses were collected through the internet. The researcher stored the collected information a password protected remote database. The researcher also collected data from filled-in questionnaires and were stored in locked cabinets. The researcher will destroy this data after four years from the end of this research study.

Participants

The researcher selected a convenient sampling technique in which the desired participants were elementary teachers at from randomly selected schools and those juniors who were entering into the pre-service elementary education course at a research institution in Mumbai, India. All the participants met the university requirements for elementary mathematics course and the college of education's requisites which included a minimum of 3.0 grade point averages and passing of the General Knowledge test. This sample collected thirty five participants who studied mathematics curriculum. The sample was overwhelmingly Indians with a few Africans, and Koreans. Specifically, the sample had 29 Indians, 5 Africans and 1 Korean. I terms of Gender, there were 21 females with 14 males. This sample was not selected randomly. The 35 participants were randomly assigned into either group A or group B.

Treatment

The selected research participants were asked to participate in a sixty minute session during the process of treatment. The protocol below was used by the researcher to ensure that for the two randomly assigned groups, the treatment remained the same. The entire session was in a four phase's progression in which the researcher looked for punctuated and intentional experience to mathematical beliefs and creativity. The phases were: posing an open-ended mathematical problem, exposing the participants to multiple perceptions, examining the sampling solutions and posing alternative problems. After the research participants responded to all prompts, the researcher allowed them to share the responses with their colleagues. The researcher then posed another open-ended problem in the next the second phase in which the research participants were given an opportunity to attempt and respond to this problem in different perspectives. The researcher gave the participants sufficient time for them to explore different instructional methods to find solutions. In the third phase of this process, the researcher allowed the respondents to discuss their variegated responses. They were then exposed to solutions to evaluate their creative thoughts. In the last phase, the researcher posed another problem and later the participants asked to pose substitute problems from the novel problem and its solutions. The researcher then suggested that the participants change the conditions and parameters of the problems they created.

The researcher pre-tested and post-tested the research participants using AMAS tool to measure their mathematical anxiety at the start of the term. In this survey, the researcher included nine items in which each of the item was on a five-point Likert Scale with five being highly anxious while one being lowly anxious. Problem posing and mathematical creativity was measured using GACT and CAMT tools respectively.

Data Collection and Analysis

The researcher used different techniques to collect data during this study. The study used two surveys to collect data on mathematical beliefs and mathematical anxieties while the data for mathematical creativity and problem posing was collected using the traditional techniques of paper-and-pencil technique. During the first weeks of this item, the respondents were requested to log in to SurveyMonkey® and fill in the forty five items questionnaires for mathematical beliefs and eleven items for mathematical anxiety. This method allowed the participants more time to complete the survey at their convenience. To collect data on problem posing and creativity, the participants were allowed two hours to respond to GACT and CAMT at the start and at the end of the term. The researcher then entered the collected data into SPSS software v.25 for analysis. Before the analysis began, the researcher performed data screening to ensure that only complete sets of data were recorded

4. Results

The researcher organized the findings in the order of the research questions which steered this study. The study results were as follows.

What are the elementary mathematics educator's problem posing approaches and beliefs towards teaching of elementary mathematics?

The researcher conducted two-way analysis of variances (ANOVA) within subjects to determine the effects of intentional experience on problem posing as well as mathematical creativity. In this analysis, the dependent variables were problem posing alongside the mathematical creativity while the treatment groups were the subject factors. The researcher then used multivariate criteria of lambda (Λ) to test for mathematics creativity x treatment groups and the main effects of mathematical creativity. According to the results obtained; $\Lambda = 22$, $F(3, 7) = 53.17$, $p < .01$, the main effect of mathematical creativity was significant while the results of x treatment; $\Lambda = 50$, $F(3, 7) = 9.05$, $p < .01$ was also the significant for group interaction effect. These results obtained revealed that intentional experience to problem posing and mathematical creativity develops the creativity of an elementary teacher's mathematics creativity as shown in figure 1 and table 2 below.

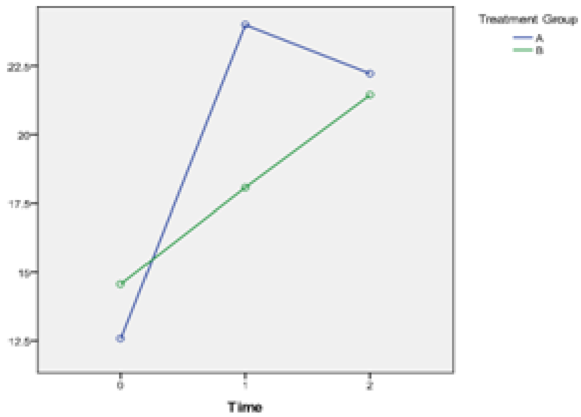

Figure 1: Problem Posing and Mathematical Creativity Results

Mathematical Creativity Scores (Standard deviations)

Table 2: General Assessment Criteria

	Time 0	Time 1	Time 2
Group A	11.49 (2.71)	25.00 (5.20)	23.91 (6.42)
Group B	15.65 (3.89)	19.17 (2.59)	20.54 (7.03)

Is there any relationship between pre-service elementary teacher's mathematical anxiety and mathematical creativity?

In this research, a paired t-test was conducted to determine if there is a relationship between mathematical anxiety and elementary mathematical teacher's creativity. The researcher tested if the posttest mean and the pretest mean were different or the same. The results for pretest means were M = 36.27, SD = 11.43 while that of the posttest for the mathematical creativity was M = 41.27, SD = 12.41, t (35) = 20.89, p > .01. The *d* effect size was 3.71. The results further indicated that the 99% confidence level for mathematical creativity was between 29.98 and 41.15 for the pretests while that of the posttests ranged from 35.73 to 48.39. Figure 2 below shows the distribution of these scores. The results exposed that there was a substantial relationship between mathematical anxiety and elementary mathematical teacher's creativity. It was also determined that intentional experience to problem posing and mathematical experience boasts pre-service elementary mathematical creativity.

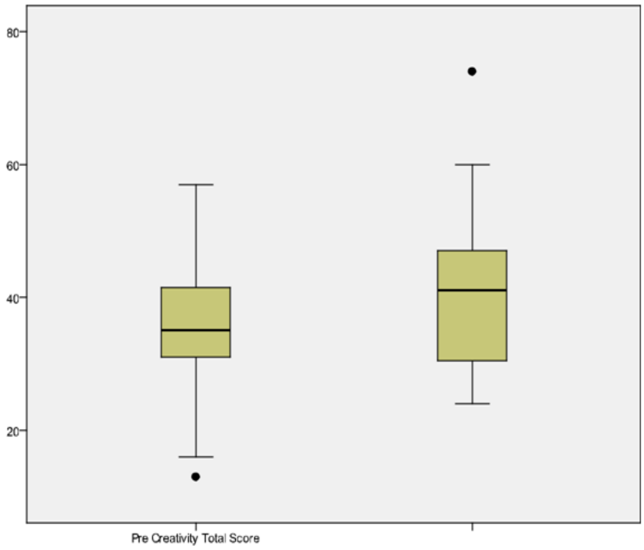

Figure 2: Boxplots for pretests and posttest using CAMT tool.

Similarly, the researcher conducted one paired t-test sample on mathematical beliefs to determine if the pretest means were significantly different from those of posttests. According to the results, the sample mean for the pretests was 151.18 while the standard deviation was 16.43 which were significantly different from those of the posttest scores whose sample mean was 192.74 while the standard deviation was 24.79. Other scores were *t* (35) = 52.31 while p = .01. The 99% confidence interval ranged from 145.71 to 159.38 on pretest scores while that of posttests ranged from 178.84 to 197.52. The *d* effect size was 8.94. Based on these empirical results, it can be concluded that intentional experience to problem posing and mathematical creativity increases the teacher's belief that mathematics is fluid. Figure 3 below represents these results.

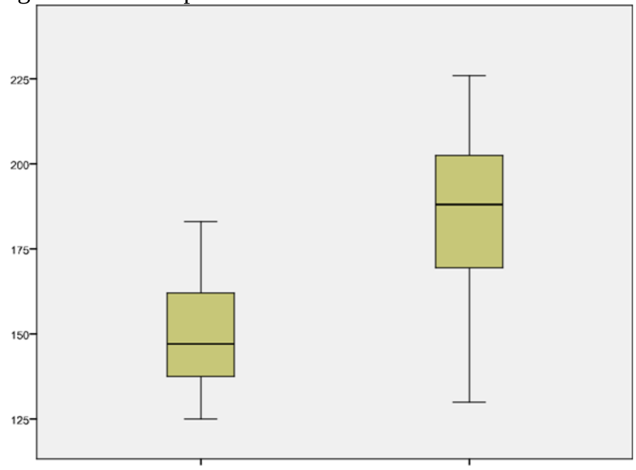

Figure 3: Boxplots for pretests and posttests for Mathematical Beliefs

Is there any significant relationship between elementary pre-service teacher's mathematical beliefs and their mathematical creativity?

In order to examine the relationship between the teacher's mathematical beliefs and their mathematical creativity, the researcher computed correlation coefficients using the variables of mathematical beliefs and mathematical creativity. The researcher determined that even though medium correlation coefficient existed between mathematical beliefs and mathematical creativity, this correlation was not significant as *r* = .271 and *p* = .075. Similarly, the correlation coefficient for posttest between mathematics belief and mathematics creativity was also not significant as *r* = -.086, *p* = .317. Based on these results, the researcher established that there was insignificant relationship between elementary teacher's mathematical beliefs and mathematical creativity. In this case, it means that a teacher's beliefs do not predict his or her mathematical creativity. These results are illustrated in Table 3 below.

Table 3: Correlations between mathematical beliefs and mathematical creativity

	Pre Test Mathematical Beliefs	Pre Mathematical Creativity	Post Test Mathematical Beliefs	Post Mathematical Creativity
Pre Test Mathematical Beliefs	1			
Pre Mathematical Creativity	.271	1		
Post Test Mathematical Beliefs	.316*	-.027	1	
Pre Mathematical Creativity	.075	.275	-.086	1

N = 35 p < .005

The researcher also computed correlation coefficients for mathematical anxiety and mathematical creativity scales. The results indicated that one out of six correlations were significant statistically as they were greater than or equal to .360. Starting from pretest, there was no significant relationship between mathematical creativity and mathematics anxiety as r = .024 while p = .511. For the posttests, the correlations between mathematical anxiety and mathematical creativity were insignificant. For instance, the results were r = -.283 while p = .049. The researcher concluded that if mathematical anxiety was higher then mathematical creativity decreased. Table 4 below shows these results.

Table 4: Correlation Coefficients

	Pre Mathematical Anxiety	Pre Mathematical Creativity	Post Mathematical Anxiety	Post Mathematical Creativity
Pre Mathematical Anxiety	1			
Pre Mathematical Creativity	.024	1		
Post Mathematical Anxiety	.511**	-.283	1	
Post Mathematical Creativity	-.184	.279	-.289	1

Note: N = 35.
***** p < .001***

Also, the researcher conducted a paired-sample t-test on the scores to determine if pretest means were significantly different from those of posttest. The results for pretests were M = 27.61 and standard deviation was SD = 5.12 which were significantly different from the posttest results whose M = 26.43 and SD = 6.28. For these results, the 99% confidence interval for pretest ranged from 23.99 to 29.31. The posttest confidence interval ranged from 23.76 to 29.97. Other scores were t (35) = 25.88, p > .01 and d = 4.81. These results were presented in Figure 5 below. The conclusion made was that intentional experience to elementary teacher's creativity lowers the teacher's mathematics' anxiety.

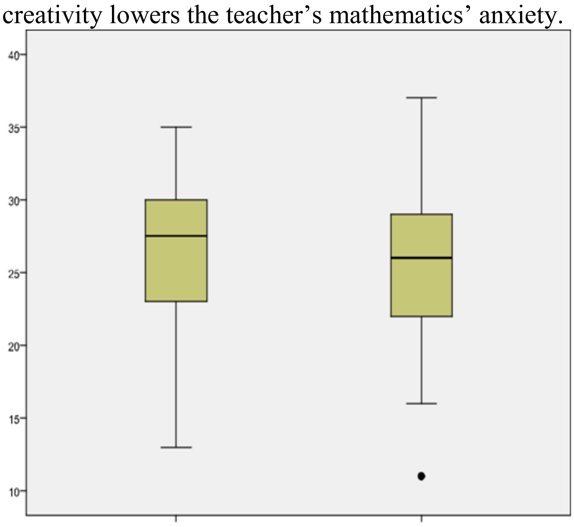

Figure 5: Boxplots of pretests and posttest mathematics' anxiety

5. Discussion, Conclusions and Recommendations

Discussion

The researcher used counterbalance design while performing a pretest and posttests to evaluate if there was any significant difference between the variables. In this study, the pre-service elementary teachers were pre-tested and post-tested during the fall semester of 2018 with four instruments. The researcher developed Mathematical Beliefs Questionnaire (MBQ) to assess the participants' mathematical beliefs. The researcher also used Felmer's, Pehkonen's and Kipatrick's instrument of Abbreviated Mathematics Anxiety Scale to measure the pre-service elementary teacher's anxiety on the nature of mathematics [9]. The researcher measured mathematical creativity and problem posing using Cai et al's General Assessment CriterialTool (GACT) [7]and Chapman's [8] Creativity Abilities in Mathematics Tool (CAMT).

It was determined that mathematical creativity is defined using three elements of originality, fluency and flexibility. In this research, the fluency referred to the quantity of responses that accepted over a given problem or prompt. Flexibility meant the differences in the responses provided by the participants while originality meant the uniqueness and the novelty of the participant's responses. In relation to first research question which was the elementary mathematics educator's problem posing approaches and beliefs towards teaching of elementary mathematics, these research made two significant findings. To begin with, using quasi-experimental design and the analysis of variance, the research study results revealed that it is possible to foster and develop mathematical creativity. Also, the researcher after using the CAMT tool for pretest and posttest data, the results indicated that there was a significant increase in mathematical creativity.

The researcher conducted two-way analysis of variances (ANOVA) within subjects to evaluate the effects of intentional experience on problem posing design and mathematics' creativity. In this analysis, the dependent variables were problem posing and mathematical creativity while the treatment groups were the subject factors. The researcher then used multivariate criteria of lambda (Λ) to test for mathematics' creativity x treatment groups and the main effects of mathematical creativity. According to the results obtained; Λ = 22, F (3, 7) = 53.17, p < .01, the main effect of mathematical creativity was significant while the results of x treatment; Λ = 50, F (3, 7) = 9.05, p < .01 was also the significant for group interaction effect. These results obtained revealed that intentional experience to problem posing and mathematical creativity progresses the creativity of an elementary teacher's mathematical creativity. Table 5 below shows the findings for RQ1.

Table 5: Findings for RQ1

Research Question	Instrument	Pre-Test Score	Post-Test Score	Results	Statistical Test
RQ 1	General Assessment Criteria	A 11.49 (2.71)	A 25.00 (5.20)	Significant	ANOVA
		B 15.65 (3.89)	B 19.17 (6.)		
	Creative Ability in Mathematics	37.14 (9.64)	39.38 (7.03)	Significant	*t* test

The researcher tested if the posttest mean and the pretest mean were different or the same. The results for pretest means were M = 36.27, SD = 11.43 while that of the posttest for the mathematical creativity was M = 41.27, SD = 12.41, t (35) = 20.89, p > .01. The *d* effect size was 3.71. The results further indicated that the 99% confidence level for mathematical creativity was between 29.98 and 41.15 for the pretests while that of the posttests ranged from 35.73 to 48.39. Figure 2 below shows the distribution of these scores. The results revealed that there was a significant relationship between mathematical anxiety and elementary mathematical teacher's creativity. It was also determined that intentional experience to problem posing and mathematical experience boasts pre-service elementary mathematical creativity.

Table 6: RQ 2 Findings

Research Question	Instrument	Pre-Test Score	Post-Test Score	Results	Statistical Test
RQ 2	Mathematics	151.64	189.44	Significant	*t* test
	Belief Questionnaire	(16.87)	(22.17)		

Based on the findings above, the researcher determined that it was difficult to change mathematical beliefs of an elementary teacher. The results also revealed that intentional experience to teacher's mathematical creativity affected their mathematical beliefs.

6. Conclusions

This study points out three significant conclusions. From the empirical evidence presented in this study, it was concluded that intentional experiences in problem posing and mathematical creativity changes the perspective of elementary mathematics teacher's general beliefs on mathematical nature its concepts. Similarly, the research concluded that intentional experience fosters the teacher's mathematical creativity. Also, the researcher determined that intentional experience in mathematical creativity lowers the level of anxiety even though anxiety often appears to be pandemic to a mathematics class. The researcher also concluded that it was significant to change the beliefs and mathematical creativity. The researcher determined that problem posing approach was a significant instructional methodology and all the participants who used it to all the prompts given to them improved their creativity and also arrived an accurate solution to a particular problem. These study findings have revealed that young learners should be exposed to appropriate situations that start from real life problems so that they can enhance their mathematical creativity. Teachers also need to employ problem posing technique to allow learners reflect on theories and mathematical concepts they learned previously so that they can enhance their critical thinking to develop an action towards a given mathematical problem.

7. Recommendations

This research study investigated how the variables of problem posing, mathematical creativity, mathematical anxiety and mathematical beliefs correlate. The researcher recommends that a further research be carried out on the teacher's beliefs about problem posing technique which might give a better understanding of how different teachers view this approach. Another study can also be carried out to determine if elementary education teachers can have instructional techniques which are consistent to their beliefs. The researcher also recommends that a study be done experiment on how elementary learners can examine their problem solving skills in mathematics which might help to understand how different teacher's behavior reform mathematical movements.

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