LOOK ACADEMIC PUBLISHERS
OPEN ACCESS

IEJME — MATHEMATICS EDUCATION
2016, VOL. 11, NO. 10, 3521-3536

Mathematics Teachers' Perceptions on Enhancing Students' Creativity in Mathematics

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ABSTRACT

Creativity is a necessary and vital tool for dealing with the economic, environmental, and humanitarian challenges of the 21st century. It is also a necessary tool for brainstorming, strategizing, and solving problems. Exploratory survey design and quantitative research method were used. 102 in-service mathematics teachers were selected using stratified random sampling from two programs. The data was collected by a likert scale, and analyzed by mean, standard deviation, correlation, independent sample t-test, one-way and two-way ANOVA. Most of the in-service mathematics teachers felt that they encourage and reward students' creative ideas and different approaches in their work; motivate students engaging with mathematics; apply regularly strong background knowledge in mathematics; allow mistakes and encourage learning from their mistakes; encourage mental flexibility; explore the environment to stimulate curiosity about their world; ask questions to students and guide them to do problems differently; encourage dissent and diversity; and provide regularly positive feedback.Therefore, training given to mathematics teachers; teachers identify mathematically creative students and apply appropriate teaching methods and assessment techniques; creativity should be made compulsory and integrated in all school mathematics curriculum; schools create of the creative environment; awareness given to parents and the Ministry of Education review the Teacher Education program.

KEYWORDS
Creativity, program, level of teaching, service year, mathematics

ARTICLE HISTORY
Received 15 September 2016
Revised 10 November 2016
Accepted 22 November 2016

Introduction

Mathematicians and researchers in mathematics education as well as psychologists have examined mathematical creativity under their various scientific viewpoints (Sriraman, 2004). Teachers must be prepared to appreciate the beauty and creativity of mathematics. They must explore the world of mathematics before they can help their students discover it. It is easy for teachers to forget the value of the struggle they may have encountered as they learned mathematics as children and fall into a teaching practice that involves demonstration by teacher and replication by the student (Pehkonen, 1997).

There are many definitions of creativity. A number of them suggest that creativity is the generation of imaginative new ideas (Newell & Shaw, 1972), involving a radical newness innovation or solution to a problem, and a radical reformulation of problems. Other definitions propose that a creative solution can simply integrate existing knowledge in a different way. A third set of definitions proposes that a creative solution, either new or recombined, must have value (Higgins 1999). A novel idea is not a creative idea unless it is valuable or it implies positive evaluation. Also, according to dtOgilvie (1998), imagination, which involves the generation of ideas not previously available as well as the generation of different ways of seeing events, is important to achieve creative actions. Runco (1993) describes creativity as a multifaceted construct involving both “divergent and convergent thinking, problem finding and problem solving, self-expression, intrinsic motivation, a questioning attitude, and self-confidence”. Haylock (1987) summarized many of the attempts to define mathematical creativity. One view “includes the ability to see new relationships between techniques and areas of application and to make associations between possibly unrelated ideas” (Tammadge, as cited in Haylock, 1987). The Russian psychologist Krutetskii characterized mathematical creativity in the context of problem formation (problem finding), invention, independence, and originality (Haylock, 1997). Others have applied the concepts of fluency, flexibility, and originality to the concept of creativity in mathematics (Haylock, 1997; Kim, Cho & Ahn, 2003). Fluency is the ability of producing many ideas; flexibility refers to the number, the degree and the focus of approaches that are observed in a solution; and originality refers to the possibility of holding extraordinary, new and unique ideas (Gil, Ben-Zvi & Apel, 2007).

Creative thinking in a disciplined manner can play a real role in innovation. “Creativity and innovation are normally complementary activities, since creativity generates the basis of innovation, which, in its development, raises difficulties that must be solved once again, with creativity…It is not possible to conceive innovation without creative ideas, as these are the starting point.” (European Commission, 1998). Innovation results when creativity occurs within the right organisational culture. The right organisational culture is one that provides through creativity processes (creative techniques) the possibilities for the development of personal and group creativity skills. We can define creativity as the establishment of skills by implementing creativity generation techniques.

Mathematics achievement is typically measured by tests of analytical thinking. Within the theoretical framework of triarchic thinking/successful intelligence, creative and practical thinking are also likely correlates of student achievement (Sternberg, 2006, 2009; Sternberg & Rainbow Project, 2006). Sriraman (2004) believes that creativity is not only associated to just the original work of mathematicians but also discovering something not already known by one, even if the result is hitherto known to others.

The essence of mathematics is thinking creatively, not simply arriving at the right answer (Ginsburg, 1996). In seeking to facilitate the development of talented young mathematicians, neglecting to recognize creativity may drive the creatively talented underground or, worse yet, cause them to give up the study of mathematics altogether. Hong and Aqui (2004) studied the differences between academically gifted students who achieved high grades in school mathematics and the creatively talented in mathematics, students with a high interest, who were active and accomplished in mathematics but not necessarily high achieving in school mathematics. As they were examining differences, their study did not include students with strengths in both areas. Hong and Aqui found significant differences in cognitive strategies used by the two groups with the creatively talented being more cognitively resourceful.

Instructional Methods Enhancing Mathematics Creativity

Teachers identified the following factors which hinder creativity: the use of one right answer, no mistakes, ignored ideas, competition, evaluation, and insufficient knowledge (Fleith, 2000; Shriki, 2008). Other inhibiting characteristics mentioned by teachers include strict discipline, drill work, emphasis on curriculum and lack of time due to various external pressures such as covering the syllabus and helping students succeed in exams (Fleith, 2000; Shriki, 2008). Consequently, teachers tend to emphasize memorization and rote thinking in teaching rather than creativity. Johny (2008) found that mathematical creativity was significantly and inversely related to mathematics anxiety.

In order to enhance the creativity of the students, Horng and colleagues (2005) argued that teachers should serve more as facilitators, learning partners, inspirers or navigators than as lecturers. In a study conducted by Shriki (2008), teachers believe that a creative environment should include open-ended activities and non-routine problems that give students freedom to apply imaginative ideas and find novel methods or solutions. Kwon, Park and Park (2006) also proposed the use of open-ended problems for developing students' creativity in mathematics. Institute for Educational Research conducted a six-year research study that evaluated higher-order mathematical thinking using open-ended problems (problems with multiple correct answers). In a round-table review of the study, Sugiyama from Tokyo Gakugei University affirmed this approach as a means to allow students to experience the first stages of mathematical creativity (Becker & Shimada, 1997).

Various research studies reported on the feasibility and success of a modelling approach in mathematics wherein rich, complex, open tasks are used to construct meaningful mathematical knowledge to prepare learners for everyday life, tertiary studies and their future careers (Biccard 2010; Niss, Blum, & Galbraith 2007; Mousoulides, Sriraman, & Christou 2007). Literature also points out that such model-eliciting tasks can be used as instruments to develop creativity and to identify creative giftedness (Fox 2006; Freiman 2006).

The use of a variety of teaching methods and aids such as technology, consist of key factors that improve students' creativity (Horng et al., 2005). According to Sriraman's definition, at the school levels, some researchers believe that creativity in mathematics is generally associated with problem solving or problem posing (Liljedahl & Sriraman, 2006; Ellwood et al., 2009; Posamentier, Smith & Stepelman, 2010). Also, there is a great overlap between the literature on creativity and that on problem-solving (Ellwood et al., 2009). Plucker, Beghetto and Dow (2004) consider creativity as an important component of problem solving. Mathematics educators have acknowledged that problem-posing and problem-solving, along with overcoming fixation are the aspects necessary for the development of mathematical creativity (Sriraman, 2005; Bolden, Harries & Newton, 2009). Cooperative interaction has considerable impact on the stimulation of creativity (Sriraman, 2005; Neumann, 2007; Shriki, 2010). Keeping this in view, the strategy was designed on the premise that mathematical creativity can be fostered with the help problem posing and problem solving activities in a cooperative learning environment with proper feedback.

Gulati (1988) has correctly suggested some ways to develop creativity in school students, "The major thrust is on group discussions, participatory activities, practicum, assignments and field visits for observation of creative activities." Kumar (2004) also suggests the mathematics teachers to become a better teacher by making teaching student-centre and activity based. For better learning and achievement in mathematics Mehra & Thakur (2008) have suggested cooperative learning. One of the characteristics of effective environments for fostering mathematical creativity is the interactive environment (Neumann, 2007). Although a new idea usually is attributed to the creator of that idea, it is result of interaction with others and pervious experiences of students who worked on this idea. After studying creative students' thinking processes such as Einstein, this reality was exposed that many of their creative insights relied on cooperation, collaboration and social support (John-Steiner, 2000). Sawyer (2007) expresses that collaboration is as a secret key to creative breakthroughs. According to Fleith (2000), teachers believe that students' cooperation with classmates of similar interests fosters creativity.

Creativity invites experimentation, formulation of new hypotheses, and opens possibilities. Creativity involves personality, affect, motivation, culture, potential, and beliefs (Ivcevic, 2009). With so many variables, the definition of the word itself is quite elusive (Hope, 2010). Sheffield (2009) argued that a task which can be extended and thus promotes further questioning can promote mathematical creativity. Undoubtedly the task alone cannot promote mathematical creativity. One of the major positive beliefs of the last decade is that creativity is of a dynamic nature and consequently it is possible to develop teachers' knowledge and skills with the aim to enhance indirectly students' mathematical creativity. Creativity needs time to develop and thrives on experience (Mann, 2006).

Kumar (2008) has suggested utilise unconscious and oral evaluation and has also focused on the utility of training the mathematics teacher in techniques of evaluation. Agrawal (2007) has put emphasis on constructivist evaluation which is very much essential for evaluation in mathematics specially as creative evaluation technique.

Statement of the Problem

Teachers are supposed to provide appropriate classroom atmosphere for creativity in mathematics education, since it is well acknowledged that basics of creative thought are developed at the earlier ages of primary education (Leikin & Pitta-Pantazi, 2013). In order to be able to foster their students' mathematical creativity teachers should acquire suitable pedagogical knowledge during their training (Shriki, 2008); however many teachers admit to a lack of prior experience or proper preparation on developing students' creativity (Shriki, 2010). Pre-service programs have to explicitly explore with students what it means to be creative if future teachers will be able to foster their students' mathematical creativity (Levenson, 2013).

However, creativity is often neglected in mathematics teaching. Devlin (2000) identified four facets of mathematics teaching as: computational, formal reasoning, and problem solving; a way of knowing; a creative medium; and applications. Of these facets, he pointed out that current teaching practices focus on the first, partly touch on the fourth, and ignore the other two. Hong and Aqui (2004) stressed that mathematical competence is equated with speed and accuracy of a student's computation with little emphasis on problem solving, reasoning and proof, communication, connection and representation. Students have very limited opportunities to experience mathematical activities that require creative thinking.

Objectives of the Study

The general objective of this study was to assess the perception of in-service mathematics teachers enhancing students' creativity in mathematics.

The specific objectives of the study were:

1) To analyze the extent of the in-service mathematics teachers enhancing students' creativity in mathematics,
2) To check whether there are significant differences in the responses of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to program, level of teaching and service year.
3) To see the interaction effect between program, level of teaching and service year on the dependent variable of enhancing students' creativity in mathematics.

Research Questions

The research questions for the study were:

1) To what extent the in-service mathematics teachers enhancing students' creativity in mathematics?
2) Is there a significant difference in the responses of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to program?
3) Is there a significant difference in the responses of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to level of teaching?
4) Is there a significant difference in the responses of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to service year?
5) Are there significant interaction effect between program, level of teaching and service year on the dependent variable of enhancing students' creativity in mathematics?

Materials and Methods

Research Design

The present study used exploratory survey design. The method used for this study was quantitative research method and it focused on a Likert scale questionnaire.

Population and Sampling Method

The population for this study consisted of all 306 in-service mathematics teachers in Addis Ababa University. 102 in-service mathematics teachers were selected using stratified random sampling, and out of these 102 in-service mathematics teachers, 63 were master teachers and 39 were PGDT teachers; 30 were teaching in primary schools, 32 were teaching in secondary schools and 40 were teaching in preparatory schools; and 38 had short teaching service year, 32 had average teaching service year, and 32 had long teaching service year.

Instruments of Data Collection

A Likert scale on "In-service mathematics teachers' perceptions on enhancing students' creativity in mathematics" which had 13 items, and all the items assessed in terms of a 1-5 Likert-type scale and the respondents were asked to respond to each item using a five point scale ranging strongly agree to strongly disagree such as strongly agree = 5, agree = 4, neutral = 3, disagree = 2 and strongly disagree = 1.

Validity and Reliability of the Instruments

The scale of teachers' perceptions on enhancing students' creativity in mathematics was reviewed based on the comments of professionals for the face and content validity. A pilot study was conducted to determine the validity and reliability of the scale. Thirty in-service mathematics teachers which are not included in the main study were taken from Addis Ababa University. From the pilot study the alpha coefficient of Cronbach yielded 0.834 for the scale ‘enhancing students' creativity in mathematics’. The Cronbach Alpha Coefficients of reliability for this variable indicated that they have high internal-consistency reliability.

Method of Analysis

Since the creativity scale was an ordinal of 5 levels Likert scale and the skewness of the distribution for all 13 items lied between -1 and +1, this indicated that the data is not significantly different from normal. These justify that the variable is distributed approximately normally and we can use inferential statistics. Therefore, the data analysis techniques used for this study were Mean, Standard Deviation, Independent t-test, One way and Two way ANOVAs.

Result

The first research question was to what extent the in-service mathematics teachers enhancing students' creativity in mathematics? In order to answer this question, 13 items were administered to the respondents to assess the items using a five - point scales rating starting from strongly agree to strongly disagree. Table 1 presents the descriptive statistics of the responses of in-service mathematics teachers enhancing students' creativity in Mathematics.

Table 1: Descriptive statistics of the responses of in-service mathematics teachers enhancing students' creativity in mathematics

No	Items	N	Mean	SD
1	I reward creative ideas and products through public recognition - even if the ideas are still developing or perhaps fail.	102	3.60	.981
2	I encourage students to take unique and different approaches in their work and reward any efforts in this direction.	102	3.90	.866
3	I help students to come up with unique outcomes (solutions or new problems)	102	3.96	.958
4	I motivate students engaging with mathematics	102	4.38	.760
5	I regularly applies strong background knowledge in mathematics	102	3.94	.936
6	I elicit creativity on the part of students	102	3.69	.946
7	I value creativity on the part of students	102	4.02	.860
8	I allow mistakes and model and encourage learning from their mistakes.	102	3.97	.911
9	I encourage mental flexibility - taking other viewpoints that they might not usually take.	102	3.87	.796
10	I explore the environment to stimulate curiosity about their world.	102	3.63	.771
11	I question students' assumptions and guide them to do problems differently and consider their beliefs and others' to expose students to other ideas.	102	3.94	.705
12	I encourage dissent and diversity.	102	3.83	.949
13	I regularly provide positive feedback.	102	4.23	.947
	Enhancing students' creativity in mathematics classroom	**102**	**3.912**	**.515**

As can be seen from the above table of the items of problem solving of ***'enhancing students' creativity in mathematics'*** are: rewarding creative ideas and products through public recognition (3.60), encouraging and rewarding students to take unique and different approaches in their work (3.90), helping students to come up with unique outcomes (3.96), motivating students engaging with mathematics (4.38), applying regularly a strong background knowledge in mathematics (3.94), eliciting creativity on the part of students (3.69), valuing creativity on the part of students (4.02), allowing mistakes and model and encourage learning from their mistakes (3.97), encouraging mental flexibility - taking other viewpoints that they might not usually take (3.87), exploring the environment to stimulate curiosity about their world (3.63), asking questions students' assumptions and guide them to do problems differently and consider their beliefs and others' to expose students to other ideas (3.94), encouraging dissent and diversity (3.83), and providing regularly a positive feedback (4.23) rated as the mean score values are above average. For the aggregate of all the items of '***enhancing enhancing students' creativity in mathematics***' average value of the responses is 3.912, which is also above average.

Below is the analysis of the second research question that was 'Is there a significant difference in the responses of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to program?'

Program

In order to examine the significant differences of in-service mathematics teachers enhancing students' creativity in mathematics with respect to their program independent sample t-test was used. Table 2 below shows descriptive statistics and independent sample t-test for in-service mathematics teachers enhancing students' creativity in mathematics with respect to their program.

Table 2: Descriptive statistics and t-test for the responses of in-service mathematics teachers enhancing students' creativity in mathematics with respect to their program

Components	Program	N	M	SD	t	df	p
Enhancing students' creativity in mathematics classroom	PGDT	39	3.990	.47914	1.213	100	.228
	Master	63	3.863	.53338			

From Table 2, the descriptive statistics showed that the mean response of in-service PGDT mathematics teachers (3.990) had greater mean response than that of in-service Masters Mathematics teachers (3.863) for enhancing students' creativity in mathematics. From the same table of an independent sample t-test indicated, t-value was not statistically significant difference between in-service PGDT and Masters mathematics teachers in the cases of enhancing students' creativity in mathematics ($t = 1.213$, $df = 100$, $p > 0.05$). Thus, in-service PGDT and Masters Mathematics teachers had similar mean responses in enhancing students' creativity in mathematics.

Below is the analysis of the second research question that was 'Is there a significant difference in the responses of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to level of teaching?'

Level of Teaching

One-way ANOVA test was used to see the significance differences of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to level of teaching. Table 3 shows descriptive statistics and ANOVA test for in-service mathematics teachers enhancing students' creativity in mathematics with respect to level of teaching.

Table 3: Descriptive statistics and ANOVA test for the responses of in-service mathematics teachers enhancing students' creativity in mathematics with respect to level of teaching

Components	Level of Teaching	N	M	SD	F	p
Enhancing students' creativity in mathematics classroom	Primary	30	3.9718	.48123	4.401	.015
	Secondary	32	4.0745	.46091		
	Preparatory	40	3.7365	.53744		

Table 3 of the descriptive statistics showed that the mean response of secondary in-service mathematics teachers (4.0745) had the highest and preparatory in-service mathematics teachers (3.7365) had the least mean responses in enhancing students' creativity in mathematics. From the table, as ANOVA test indicated, F-value was statistically significant difference between the level of teaching groups for enhancing students' creativity in mathematics ($F(3, 99) = 4.401$, $p < .05$). This indicates that primary, secondary and preparatory in-service mathematics teachers had significantly different in the responses of enhancing students' creativity in mathematics.

Since the variable enhancing students' creativity in mathematics made statistically significant differences with respect to level of teaching, Tukey HSD test is used in order to compare the mean difference of enhancing students' creativity in mathematics with respect to the level of teaching such as primary, secondary and preparatory mathematics teachers. Table 4 below indicates the Tukey HSD tests of the significant of mean difference of scores of enhancing students' creativity in mathematics made statistically significant differences with respect to level of teaching.

Table 4: *Tukey test of the significant mean difference of scores of enhancing students' creativity in mathematics with respect to level of teaching*

Components	Region (I)	Region (J)	MD (I-J)	SE	p
Enhancing students' creativity in mathematics classroom	Primary	Secondary	-.10272	.12659	.697
		Preparatory	.23526	.12031	.129
	Secondary	Primary	.10272	.12659	.697
		Preparatory	.33798(*)	.11814	.014
	Preparatory	Primary	-.23526	.12031	.129
		Secondary	-.33798(*)	.11814	.014

* The mean difference is significant at the .05 level.

The Tukey HSD Test from Table 4 above indicates that the preparatory in-service mathematics teachers significantly different from secondary in-service mathematics teachers (MD = -.33798, $p < .05$) for the variable enhancing students' creativity in mathematics. This indicates that preparatory in-service mathematics teachers' response significantly negatively deviated from secondary in-service mathematics teachers in the variable enhancing students' creativity in mathematics.

Below is the analysis of the second research question that was 'Is there a significant difference in the responses of the in-service mathematics teachers enhancing students' creativity in mathematics with respect to service year?'

Service Year

One-way ANOVA test was used to see the significance differences of in-service mathematics teachers enhancing students' creativity in mathematics with respect to service year. Table 5 shows descriptive statistics and ANOVA test for in-service mathematics teachers enhancing students' creativity in mathematics with respect to service year.

Table 5: Descriptive statistics and ANOVA test for the responses of in-service mathematics teachers enhancing students' creativity in mathematics with respect to service year

Components	Service year	N	M	SD	F	p
Enhancing students' creativity in mathematics classroom	Short	38	3.9575	.49001	.865	.424
	Average	32	3.9567	.51247		
	Long	32	3.8125	.54671		

Table 5 of the descriptive statistics showed that the mean response of short teaching service year of the in-service mathematics teachers (3.9575) had the highest mean response whereas long teaching service year of the in-service mathematics teachers (3.8125) had the least mean response on enhancing students' creativity in mathematics. From Table 5, as ANOVA test indicated, F-value was not statistically significant difference between the service year groups for enhancing students' creativity in mathematics ($F(3, 99) = .865$, $p > .05$). This indicates that short, average and long teaching service year of the in-service mathematics teachers had nearly similar mean responses on the variable enhancing students' creativity in mathematics.

Below is the analysis of the fifth research question that was ‘Are there a significant interaction effect between program, level of teaching and service year on the dependent variable of enhancing students' creativity in mathematics?’

The GLM Univariate procedure provides an analysis for main and interaction effects with the dependent variable of enhancing students' creativity in mathematics.

Table 6: Analysis of Variance for in-service mathematics teachers enhancing students' creativity in mathematics as a function of program, level of teaching and service year

Variable and source	df	Mean Square	F	p	Partial Eta Squared
Enhancing students' creativity in mathematics classroom					
Program	1	.004	.016	.901	.000
Level of teaching	2	.016	.069	.933	.002
Service year	2	.102	.438	.647	.010
Program * Level of teaching	1	2.427	10.431	.002	.104
Program * Service year	1	.134	.273	.232	.001
Level of teaching * Service year	3	.163	.703	.553	.023
Program * Level of teaching * Service year	1	.161	.318	.123	.001
Error	90	.233			

The findings of the GLM Univariate (Table 6) yielded there was no main effect of program on enhancing students' creativity in mathematics ($F = .016$, $p > 0.05$, $eta^2 = .000$); there was no main effect of level of teaching on enhancing students' creativity in mathematics ($F = .069$, $p > 0.05$, $eta^2 = .002$); and also there was no main effect of service year on enhancing students' creativity in mathematics ($F = .438$, $p > 0.05$, $eta^2 = .010$). Furthermore, there were not significant interaction effect between program, level of teaching, and service year ($F = .318$, $p > 0.05$, $eta^2 = .001$); between program and service year ($F = .273$, $p > 0.05$, $eta^2 = .001$); and between level of teaching and service year ($F = .703$, $p > 0.05$, $eta^2 = .023$); but there is a significant interaction effect between program and level of teaching ($F = 10.431$, $p < 0.05$, $eta^2 = .104$) on enhancing students' creativity in mathematics. Thus it can be concluded that program, level of teaching, and service year were not significantly related with the dependent variable enhancing students' creativity in mathematics, but program and level of teaching had a significant interaction effect on the dependent variable enhancing students' creativity in mathematics and in all cases according to Cohen (1988), the eta values indicate that the effect is small to very small.

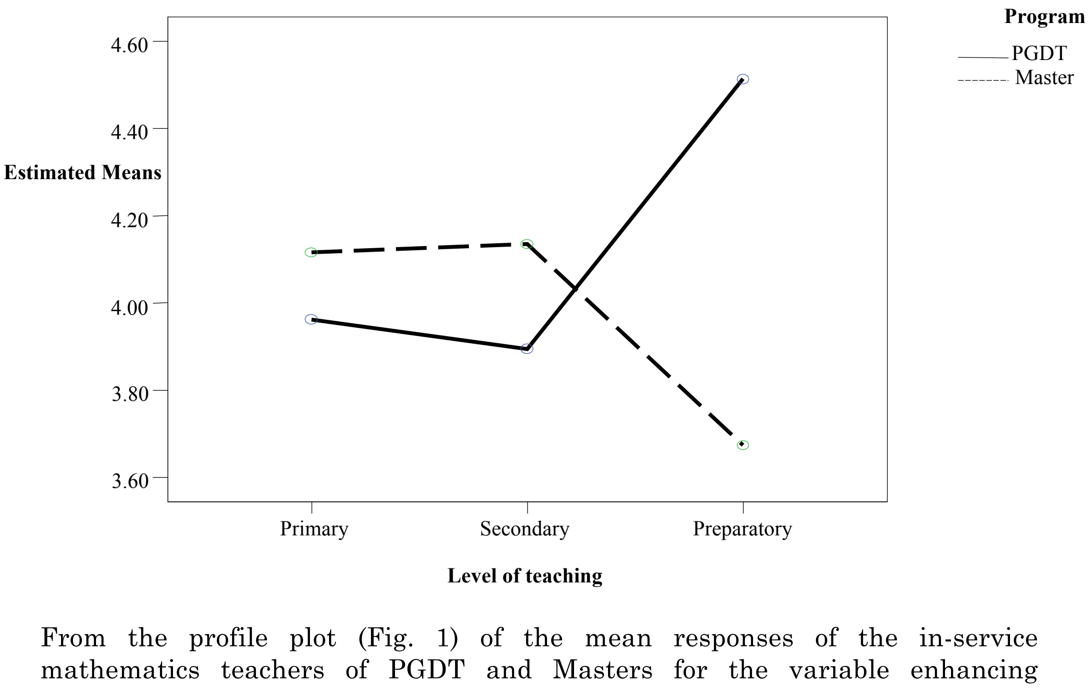
Below is the descriptive statistics of the two programs and three level of teaching on the variable of enhancing students' creativity in mathematics.

Table 7: *Descriptive statistics for the variable 'Enhancing students' creativity in Mathematics' for the two programs and three level of teaching*

Variable	Groups	PGDT			Masters		
		N	M	SD	N	M	SD
Enhancing students' creativity in mathematics classroom	Primary	28	3.9615	.49432	2	4.1154	.27196
	Secondary	8	3.8942	.40273	24	4.1346	.47106
	Preparatory	3	4.5128	.19359	37	3.6736	.50650

The descriptive statistics of table 7 indicates that the mean responses of the in-service mathematics teachers of PGDT (4.5128) were significantly greater than the mean responses of the in-service mathematics teachers of Masters (3.6736) for teaching in the preparatory schools; the mean responses of the in-service mathematics teachers of PGDT (3.9615) were significantly less than the mean responses of the in-service mathematics teachers of Masters (4.1154) for teaching in the primary schools; and the mean responses of the in-service mathematics teachers of PGDT (3.8942) were significantly less than the mean responses of the in-service mathematics teachers of Masters (4.1346) for teaching in the secondary schools for the variable of enhancing students' creativity in mathematics classroom.

Fig 1: Estimated Marginal Means of Enhancing students' creativity in mathematics classroom



From the profile plot (Fig. 1) of the mean responses of the in-service mathematics teachers of PGDT and Masters for the variable enhancing students' creativity in mathematics classroom, the differences between the cell means of the in-service mathematics teachers of PGDT were larger than the in-service mathematics teachers of Masters for teaching in the preparatory schools (difference cell means = 0.8392), but the difference between the mean responses of the in-service mathematics teachers of PGDT and Masters were small for teaching in the primary schools (difference cell means = 0.1539) and teaching in the secondary schools (difference cell means = 0.2404).

Discussion

Creativity is a necessary and vital tool for dealing with the economic, environmental, and humanitarian challenges of the 21st century (Sheridan-Rabideau, 2010) and helps prepare children for the real world (Sternberg, 2006). Creativity is a basic requirement that is highly respected and valued in most disciplines and professions (Gardner, 2009; Christensen, Johnson, & Horn, 2008). Creativity is a necessary tool for brainstorming, strategizing, and solving problems (Wallace, Abbott, & Blary, 2007). Creative problem solving can be developed through integration of the arts and student-led problem solving strategies. In this study most of the in-service mathematics teachers responded that they apply a strong background knowledge in mathematics and real-life application; motivate students to engage with mathematics, encourage dissent and diversity ideas and come up with unique outcomes by applying different approaches in their work; encourage the mental flexibility of the students, elicit and reward the creative ideas and products of the students; allow mistakes and model and encourage learning from their mistakes; ask questions students' assumptions and guide them to dig deeper and provide regularly a positive feedback. The aggregate mean of all the items of *enhancing students' creativity in mathematics* is above average. Comparing the responses of teachers with respect to program of teaching, level of teaching and teaching service year: the PGDT and Masters; and short, average and long teaching service year of the in-service mathematics teachers had similar responses in enhancing students' creativity in mathematics. But, the primary, secondary and preparatory in-service mathematics teachers had significantly different in the responses of enhancing students' creativity in mathematics; that is, the preparatory in-service mathematics teachers' response significantly negatively deviated from secondary in-service mathematics teachers in the variable enhancing students' creativity in mathematics. The findings of the GLM Univariate yielded there was no main effect of program, level of teaching and service year on enhancing students' creativity in mathematics. Furthermore, there were not significant interaction effect between program, level of teaching, and service year; between program and service year; and between level of teaching and service year; but there is a significant interaction effect between program and level of teaching on enhancing students' creativity in mathematics. That is, the average responses of the PGDT mathematics in-service teachers were significantly greater than the Masters for teaching in the preparatory schools; the PGDT mathematics in-service teachers were significantly less than the Masters for teaching in the primary schools; and the PGDT mathematics in-service teachers were significantly less than the Masters for teaching in the secondary schools for the variable of enhancing students' creativity in mathematics classroom.

Teachers apply strong background knowledge in mathematics and real-life application; and motivate students to engage with mathematics. By applying learned strategies, a student can systematically apply multiple methods to solve a problem but never exploring areas outside the individual's known content-universe. To encourage the development of mathematical creativity, teachers need to enable creative exploration and reward students who seek to expand their content-universe. In line with this Shriki (2008), Kwon, Park and Park (2006), and Kwon, Park and Park (2006) suggested that teachers should facilitate the creative environment by including higher-order mathematical thinking using open-ended activities and non-routine problems that give students freedom to apply imaginative ideas and find novel methods or solutions; Neumann (2007) proposed interactive environment, it is result of interaction with others and pervious experiences of students. In addition, Biccard (2010), Niss, Blum, & Galbraith (2007), and Mousoulides, Sriraman, & Christou (2007) suggested modelling approach in mathematics to construct meaningful mathematical knowledge to prepare learners for everyday life; Sriraman (2004) suggested that teachers must be prepared to appreciate the beauty and creativity of mathematics by exploring the world of mathematics before they can help their students discover it; and Newell & Shaw (1972) proposed that a creative solution can simply integrate existing knowledge in a different way.

Teachers encourage dissent and diversity ideas and come up with unique outcomes by applying different approaches in their work; encourage the mental flexibility of the students, elicit and reward the creative ideas and products of the students; allow mistakes and model and encourage learning from their mistakes. Divergent thinking is one of prevalent descriptors of mathematical creativity, and mathematical creativity as an ability to analyze a given problem from different perspective, see patterns, differences and similarities, generate multiple ideas and choose a proper method to deal with unfamiliar mathematical situations. In line with this, Newell & Shaw (1972) proposed that a creative solution can simply integrate existing knowledge in a different way; and Runco (1993) describes creativity as a multifaceted construct involving both "divergent and convergent thinking, problem finding and problem solving, self-expression, intrinsic motivation, a questioning attitude, and self-confidence". Haylock (1997) and Kim, Cho & Ahn (2003) have applied the concepts of fluency which is the ability of producing many ideas; flexibility refers to the number, the degree and the focus of approaches that are observed in a solution; and originality refers to the possibility of holding extraordinary, new and unique ideas (Gil, Ben-Zvi & Apel, 2007).

Teachers ask questions students' assumptions and guide them to dig deeper and provide regularly a positive feedback. Traditional tests do not identify or measure creativity (Kim et al., 2003) but often reward accuracy and speed. These tests identify students who do well in school mathematics and are computationally fluent, but neglect the creatively talented in mathematics. Encouraging mathematical creativity in addition to computational fluency is essential for students to have a productive and enjoyable journey while developing a deep conceptual understanding of mathematics. For the development of the mathematical talent, creativity is essential. In line with this Sheffield (2009) argued that a task which can be extended and thus promotes further questioning can promote mathematical creativity; Kumar (2008) also suggested utilise unconscious and oral evaluation and has also focused on the utility of training the mathematics teacher in techniques of evaluation. Agrawal

(2007) has put emphasis on constructivist evaluation which is very much essential for evaluation in mathematics specially as creative evaluation technique.

Teachers must be prepared to appreciate the beauty and creativity of mathematics. They must explore the world of mathematics before they can help their students discover it, and apply the appropriate teaching strategies. In line with this teachers should apply appropriate varieties of teaching methods, activities and aids such as: appropriate technology (Horng et al., 2005); open-ended activities and non-routine problems that are with multiple correct answers (Horng & colleagues (2005); Shriki (2008); Kwon, Park and Park (2006)); modelling approach in mathematics (Biccard 2010; Niss, Blum, & Galbraith 2007; Mousoulides, Sriraman, & Christou 2007); group discussions, participatory activities, practicum, assignments and field visits (Gulati, 1988); problem solving and problem posing (Liljedahl & Sriraman, 2006; Ellwood et al., 2009; Posamentier, Smith & Stepelman, 2010; Sriraman, 2005; Bolden, Harries & Newton, 2009); cooperation, collaboration and social support (John-Steiner, 2000; Sriraman, 2005; Neumann, 2007; Shriki, 2010; Mehra & Thakur, 2008); appropriate questioning (Sheffield, 2009).

Conclusions and Recommendations

Conclusions

In order to enhance the reasoning skills of the students, teachers should value classroom creativity; and help and reward students' creative ideas and products through public recognition by encouraging students to take unique and different approaches in their work. Teachers should apply regularly a strong background knowledge in mathematics by exploring the environment to stimulate curiosity about their world. At the school level, creativity in mathematics is improved by applying teaching using appropriate technology; open-ended activities and non-routine problems that are with multiple correct answers; modelling approach; group discussions, cooperation, collaboration and social support; appropriate questioning. Students should be provided and motivated to engage in struggling to solve mathematics problems which are ill posed or open ended. Solving such challenging mathematics problems could lead students to deeper understanding and experience creativity in doing mathematics and also try to think as a mathematician, which means that students are encouraged to reflect on their own ideas. For this purpose, it is necessary to improve teachers' ability to plan and implement educational environments that provide a secure atmosphere that students are encouraged to take risks; make mistakes and encourage learning from their mistakes; and interact with others and share their points of view. Teachers also encourage mental flexibility, dissent and diversity of ideas and provide regularly a positive feedback

Recommendations

Based on the findings of the study, the recommendations were as follows:

- Training should be given to mathematics teachers in different types of skills (Intellectual, Teaching, Evaluation etc.) to present the content creatively.

- Teachers identify mathematically creative students and forming the teaching group for their development of creative talents in mathematics.
- Teachers enrich the students through effective open-ended questions, communication process, organization of mathematics related co-curricular activities, creative discussions, genuine experimentation etc.
- Awareness should be given to parents in the way they could help students to foster their mathematical creative talents informally and at times non-formally.
- Schools arrange some special programmes for development of mathematical creativity.
- Teachers and school heads create of the creative environment in schools for creative expression and its development.
- Schools arrange special provisions and arrangements for counselling of mathematically creative talents.
- The curriculum developers, implementers and educational evaluators and school heads should enforce teachers to apply appropriate teaching methods and assessment techniques that enhance creativity into the teaching of mathematics.
- Creativity should be made compulsory and integrated in all primary and secondary school mathematics curriculum, scheme of work, lesson note, lesson plan and in the classroom when teaching and learning take place.
- The Ministry of Education should review of the Teacher Education programs for the development of some mechanism for developing mathematical creativity.
- The Ministry of Education should review its programs to improve the capacity of the would be teachers.

Disclosure statement

No potential conflict of interest was reported by the author.

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