Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.7, No.23, 2016 www.iiste.org

# Effects of Experiential Learning Approach on Students' Mathematical Creativity among Secondary School Students of Kericho East Sub-County, Kenya

Chesimet M. C Githua B.N Ng'eno, J. K.
Egerton University, Department of Curriculum, Instruction and Education Management, P. O. Box 536- 20115 Egerton, Kenya

**Abstract**
Mathematics is a subject which seeks to understand patterns that permeate both the world around us and the mind within us. There are many ways of thinking and the kind of thinking one learns in mathematics is an ability to handle abstraction and solve problems that require knowledge of mathematics. Mathematical creativity is essential for scientists. Creativity is one of the goals of teaching mathematics in schools. This study investigated the Effects of Experiential Learning Approach on students' mathematical creativity in Kericho East Sub-County. The topic Statistics I was taught to Form Two since it is one of the topics that is poorly performed according to KNEC reports on KCSE. Solomon Four Non Equivalent Control Group Design under the quasi-experimental research was used. A random sample of four co-educational district secondary schools was drawn from schools in Kericho East Sub-County. Each school provided one Form Two class. This translated to a total of 168 students. In the experimental groups Experiential Learning Approach (ELA) was used while Conventional Teaching Methods (CTM) was used in the control groups. One experimental and one control group was pre tested. At the end of the treatment all the four groups were post tested using Mathematical Creativity Test (MCT). The instruments were validated with the help of experts in the Department of Curriculum Instruction and Education Management of Egerton University and mathematics teachers from selected secondary schools. MCT was pilot tested to estimate its reliability coefficient using Cronbach alpha which was found to be 0.778. Descriptive as well as inferential statistics were used in data analysis. These included mean score and ANOVA. All statistical tests were subjected to test of significance at alpha (α) level of 0.05. The results revealed that ELA had a significant effect on students' mathematical creativity. The findings of the study are expected to assist mathematics teachers to adjust their instructional strategies and also teacher trainers may use the information from the study to sensitise in-service and pre-service mathematics teachers on the importance of Experiential Learning strategies in enhancing Mathematical Creativity. The findings may also be used as a basis for future research in Mathematics Education.
**Keywords**: Mathematical Creativity, Experiential Learning

## Background to the Study

Creativity has been proposed as one of the major components to be included in the education of the 21$^{st}$ century (Mann, 2005). Therefore, the contemporary curricula should emphasize the development of students' creative thinking (Lamon, 2003). There is no commonly accepted definition of mathematical creativity (Mann, 2006). However a commonly agreed on definition is that mathematical creativity is a novel way of thinking characterised by fluency, flexibility, originality and elaboration (Gill, Ben-Zvi & Apel, 2007; Leikin, Berman & Koichu, 2010; Kim, Cho & Ahn, 2003; Imai 2000; Runco, 2008). Fluency is the number of responses a learner can give to a mathematical question, flexibility is the shift in categories in the responses to a given mathematical task, originality is the degree of uniqueness of responses and elaboration is the ability of a person to produce detailed steps (Leikin, 2009).

The main goal of mathematics education is the "mathematisation" of the child's thinking. Clarity of thought and pursuing assumptions to logical conclusions is central to the mathematical enterprise (Pooja, 2012). Researchers have come up with various definitions of mathematical creativity. According to Runco (1993) creativity is a construct involving both divergent and convergent thinking, problem finding and problem solving, self expression, intrinsic motivation, a questioning attitude and self confidence. Krutetskii (1976) characterises mathematical creativity in the context of problem formation (problem finding) invention, independence and originality

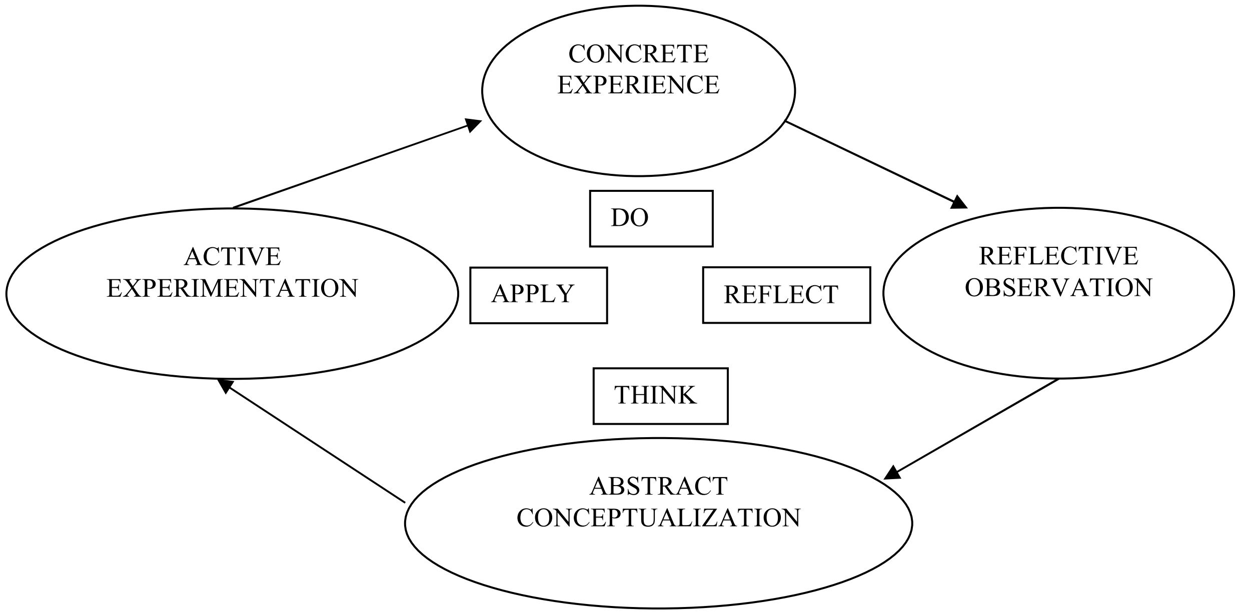
Mathematical creativity is an essential aspect in the development of mathematical talent (Mann, 2005). Mathematical creativity is also important for constructing mathematical knowledge in a more central way than merely producing learnt knowledge thus teaching of mathematics must focus on seeking solutions creatively, exploring patterns uniquely and formulating hypothesis (Jha, 2012). Despite its importance, mathematical creativity is often neglected in mathematics education.

Experiential learning approach asserts that acquisition of skills and construction of knowledge by the learners is direct result of experience. The learner is said to have the ability to select and to participate in experiences that will further their growth (Atherton, 2009). Experiential learning can exist without a teacher and relates solely to the meaning making process of the individuals' direct experience. This is in agreement with Rogers (1969) who asserts that experiential learning is equivalent to personal growth and change. According to Newsome, Wardlow and Johnson (2005) experiential learning approach elevates students' cognition levels, increases use of critical thinking skills and therefore enhances students' ability to obtain, retain and retrieve knowledge hence increased achievement.

Learning is a cycle that begins with experience continues with reflection and later leads to action which itself becomes a concrete experience for reflections. Kolb (1984) developed a model of how students can learn. In the Kolb's experiential learning model the process of learning is divided into four stages all of which must be gone through for learning to be most effective. The stages include

a) Concrete experience- this provides the basis for the learning process. The lessons at this stage engage the individual personally and learning relies on open mindedness and adaptability rather than a systematic approach to situation or problem. There is involvement in personal experiences and an emphasis on feeling over thinking. The role of the teacher is to describe the activity while the students perform. Creative work involves a certain amount of pre-existing domain knowledge and its transformation into new knowledge (Naikakoji, Yamamoto & Ohira, 1999).
b) Reflective observation – in this stage the learners make sense of the experience. They focus on understanding the meaning of ideas and concepts by careful observations. They are also concerned with how things happen by attempting to see them from different perspectives. Learning occurs as a result of patience, objectivity, careful judgement and observation. Reflection helps students break their experiences into parts and to categorize them for use in the next stage of learning. Students develop logical thoughts, verbalize those thoughts, relate to others in the group and compare experiences and opinions. The applications of classroom knowledge in the context of real world situations are the focus of learning (Arnold, Warner & Osborne, 2006). The role of the teacher is to promote an atmosphere of acceptance of individual participants and diverse thinking. For learners to become creative in mathematics learning it is important for the teacher to design activities that help learners to construct meaning and think for themselves by having a critical mathematical eye (Jha, 2012)
c) Abstract Conceptualization – this is where the learner assimilates and distils the observation and reflections into a theory. The students come to understand the general concept of which their concrete experience was one example by assembling their experience into a general model. Abstract conceptualization requires student to use logic and a systematic approach to problem solving. There is emphasis on thinking manipulation of abstract symbols and tendency to neat and precise conceptual systems. The students share their reactions and observations about their experiences. The learners at this stage provide answers to the questions arising from the experiences by providing solutions and making generalisations. According to National Council of Mathematics Teachers (NCTM) (2000) the ability to solve a problem with several strategies or the ability to reach different answers in a specific task are valuable evidences of the development of mathematical reasoning.
d) Active Experimentation – emphasis in on practical applications, testing theories that lead into new experiences. In this stage students use the theories they developed during the abstract conceptualization stage to make predictions about the real world situations. They connect subject matter and life skills discussion to the larger world. Students' actions are a new concrete experience. The learners are expected to use or test the conclusion, generalizations and solutions in new situations (Kolb & Kolb, 2008). The learner involvement facilitates personal growth and skill development, giving a measure of empowerment to the learners. Figure 1 shows these stages with the activity for each stage.




The second word in each of the four stages indicates what the learner experiences. The learner begins by having an experience that involves him or her in a situation (experience) and then reflects on the experience from several perspectives (observation). From these reflections the learner draws concepts or conclusion and formulates them into theories or models (conceptualization) that lead them to experiment or act (experimentation). In order to develop Mathematical Creativity emphasis is placed on creating authentic learning situations where learners are thinking, feeling and doing what practicing professionals do (Renzulli, Leppien & Hays, 2000) thus ELA provides such a situation.

Balka (1974) introduced a criterion for measuring mathematical creative ability. He addressed both convergent thinking characterised by determining patterns and breaking from established mind sets, and divergent thinking defined as formulating mathematical hypotheses, evaluating unusual mathematical ideas, sensing what is missing from a problem and splitting general problems into specific sub problems.

Mathematical creativity is a multifaceted construct characterised by four dimensions (Kim Cho &Ahn, 2003; Imai, 2000; Gill, Ben-Zvi & Apel, 2007; Leikin, Berman &Koichu, 2010; Jha, 2012). These include fluency, flexibility, originality and elaboration.

**Fluency**: This is the number of relevant ideas and it shows the ability to produce several different responses to a mathematical question. Usually it is simply the number of relevant responses to a mathematical task. It also relates to the continuity of ideas, flow of association and use of basic and universal knowledge (Leikin, Berman & Koichu, 2010; Mann, 2005).This skill can be developed in the students when their learning involves thinking of different ideas for writing, drawing or speaking and thinking of different ways of solving a problem.

**Flexibility**: This is generally based on the number of categories or classes represented in a learner's pool of ideas and responses. This is the shift in categories or methods in the responses to a given mathematical task. It may be defined as the ability to generate a wide range of ideas and a variety of solutions (Gill, Ben-Zvi&Apel, 2007; Leikin, Berman &Koichu 2010). The flexibility mark refers to the number of different categories of ideas and different approaches to a certain problem.

**Originality**: This is defined as statistical infrequency. It is characterised by a unique way of thinking and unique products of mental activity (Leikin, Berman &Koichu, 2010). This is when responses are novel compared to others to the same mathematical task. These are unique or unusual responses. Originality in thinking means the production of unusual far fetched, remote and clever responses (Jha, 2012). In addition an original idea should be socially useful.

**Elaboration**: is building on other ideas. It requires extending ideas, giving constructive criticism and providing details. It means the feature that someone can think or fill the need in detail.Elaboration mark refers to the number of details in solving a problem not in an absolutist fashion but in a fallibillist fashion (Jha, 2012). Elaboration in thinking means the ability of a person to produce detailed steps to make a plan work and explain it to others.

**Methodology**

The study involved Quasi-experimental research in which the researcher used the Solomon Four Non-Equivalent Control Group Design. The design is considered rigorous enough for experimental and quasi-experimental studies. The secondary school classes once constituted exist as intact groups and school authorities do not normally allow such classes to be broken up and reconstituted for research purposes (Borg & Gall, 1989; Fraenkel & Wallen, 2000). This design has an advantage over others since it controls the major threats to internal validity except those associated with interaction and history, maturity and instrumentation (Cook & Campbell, 1979). Figure 1 presents Solomon Four Non-Equivalent Group Design.

ANOVA of the Post-test Scores on MCT

| | Sum of Squares | df | Mean Square | F | P-Value |
|---|---|---|---|---|---|
| Between Groups | 3361.754 | 3 | 1120.585 | 22.576 | .000 |
| Within Groups | 8140.222 | 164 | 49.636 | | |
| Total | 11501.976 | 167 | | | |

ANOVA results show in Table 2 indicate that $F(3,164) = 22.572$, $p < 0.05$ indicating that the differences in pre-test scores of MCT for the four groups were statistically significant. Since the differences in MCT mean scores were statistically significant Ho1 which stated that there is no statistically significant difference in students' mathematical creativity between those taught through Experiential Learning Approach and those taught through Conventional Methods was thus rejected. To determine where the significant difference was, a Post Hoc multiple comparisons analysis was carried out. The tests were conducted using Tukeys post-hoc analysis tests of multiple comparisons. Tukeys analysis was preferred for this study because the group sizes were unequal and multiple comparisons were being made. Whenever there is a significant difference between the means of different groups, this test in particular shows where the differences occurred. The results of the Tukeys analysis are presented in Table3.

Table 31: Tukeys post-hoc Pairwise Comparisons of the Post-Test MCT for the Four Groups

| | | Mean Difference (I-J) | SD | P-Value |
|---|---|---|---|---|
| E1 | C1 | 9.50894* | 1.52106 | .000 |
| | E2 | 2.74762 | 1.51156 | .269 |
| | C2 | 10.55833* | 1.53098 | .000 |
| C1 | E1 | -9.50894* | 1.52106 | .000 |
| | E2 | -6.76132* | 1.54674 | .000 |
| | C2 | 1.04939 | 1.56573 | .908 |
| E2 | E1 | -2.74762 | 1.51156 | .269 |
| | C1 | 6.76132* | 1.54674 | .000 |
| | C2 | 7.81071* | 1.55650 | .000 |
| C2 | E1 | -10.55833* | 1.53098 | .000 |
| | C1 | -1.04939 | 1.56573 | .908 |
| | E2 | -7.81071* | 1.55650 | .000 |

*. The mean difference is significant at the 0.05 level.

The post-hoc results indicate that the differences in MCT mean scores of groups E1 and C1, E1 and C2, E2 and C1 and E2 and C2 were statistically significant at $p<0.05$. However there was no statistically significant difference in the means between groups E1 and E2 and groups C1 and C2. The results of the post hoc comparisons confirmed that ELA had a positive effect on students' mathematical creativity. The study found that students who were taught using ELA achieved significantly higher scores in MCT than those who were taught through the conventional methods as shown in Table 3. This is an indication that the use of ELA was more effective in improving students' mathematical Creativity as compared to the conventional teaching/learning methods. Therefore use of ELA gives learners an opportunity to become creative in mathematics by constructing meaning and having a critical mathematical thinking. ELA also helps students to develop abilities to solve problems with several strategies or the ability to reach different answers in a specific task which are valuable evidences of the development of mathematical reasoning. Mathematical Creativity at classroom setting is the process that results in novel and insightful solutions to a given problem and the formulation of new questions and possibilities that allow an old problem to be regarded from a new point of view (Sriraman, 2005). There is need therefore to come up with teaching methods that will enhance Mathematical Creativity hence the use of ELA. Experiential learning offers a critical link between the classroom and real world. The findings of this study are in agreement with those of Casanovas, Miralles, Gomez and Garcia (2010) who noted that science learning based on the experiential learning model promotes students instruction of scientific knowledge and increase the fluency and flexibility of ideas generated.

Mathematical Creativity is the ability to solve problems or to develop thinking structures, taking into account the peculiar logical – deductive nature of the discipline and of the fitness of the generated concepts to integrate into the core of what is important in Mathematics (Ervynck, 1991). According to Sriraman (2005), Liljendal and Sriraman (2006) and Freiman and Sriraman (2007) Mathematical Creativity at classroom setting is the process that results in novel and insightful solutions to a given problem and the formulation of new questions and possibilities that allow an old problem to be regarded from a new point of view. Sheffield (2009) points out that mathematical creativity include the ability to overcome fixations and connect seemingly unrelated ideas.

Creative mathematics education must be centered on the mathematisation of the learners thinking and the construction of mathematical knowledge through a mathematically thinking mind which is not an objective entity but subjective too (Jha, 2012). The main aim of creative mathematics education is to develop the creative problem solving ability in mathematics among students. Students should identify themselves with the ability to use mathematical knowledge for problem solving, ability to communicate mathematically, reason mathematically and a mathematical propensity. Students therefore need to be provided with challenging problems that can stimulate them to develop diverse and sound ways of mathematical thinking and to think creatively. Guiding students to solve a problem using several methods and strategies help students develop and extend their mathematical thinking.

According to Stoyanova and Ellerton (1996) creative thinking ability and expressive ability in the field of mathematics can be measured by open – ended or open – response problems and questions that require more than one answer. The study further argues that mathematical problem posing is the process by which, on the basis of mathematical experience students construct personal interpretations of concrete situations and from these situations formulate meaningful mathematical problems.

Limiting the use of creativity in classroom reduces mathematics to a set of skills to master and rules to memorize and this causes many children’s natural curiosity and enthusiasm for mathematics to disappear as they get older. Solid mathematical knowledge is essential for the development of mathematical creativity (Meissner, 2000). One important reason for this necessity is the fact that excellent knowledge of the content helps individuals to make connections between different concepts and types of information (Sheffield, 2009). Therefore students who are characterized by mathematical accuracy and fluency are more able to present creative thinking in new mathematical tasks providing original and meaningful solutions (Binder, 1996). Researchers have shown that there is a significant relationship between mathematical creativity and achievement (Kadir & Maker, 2011; Ganihar & Wajiha, 2009; Brunkalla, 2009). According to Brunkalla (2009) students have higher academic achievement if they like mathematics and have positive feelings about it. A study by Pooja (2012) found a positive relationship between mathematical creativity and achievement. He asserts that mathematical creativity facilitates achievement of students because students enjoy creative thinking in the use of mathematical principles. Without fear of rejection, students give multiple answers of one question, consequently knowledge understanding, skill and application is enhanced. Mathematical creativity teaching strategy has also been shown to improve achievement in mathematics (Githua & Njubi, 2013).

**Conclusion and Recommendation**

The results of the Post Test Mean Scores on MCT for the four groups were significantly different. Group E1 and E2 had means of 35.53 and 32.79 respectively while group C1 and C2 had means of 25.83 and 24.98 respectively. ANOVA results show that the difference in the mean scores between the four groups were significant. These results therefore indicated that ELA has a positive effect on students’ Mathematical Creativity. ELA instructional approach produced a significant impact on mathematical creativity among secondary school students. Mathematical creativity should be emphasised in all mathematics classes.

**References**

Atherton, J.S. (2009). *Learning and Teaching External Learning* http://www.learning and teaching.info/learning/experience.html.

Balka, D. S. (1974). Creative Ability in Mathematics*, Arithmetic Teacher* 21’ 633-636

Binder, C. (1996).Behavioural Fluency.Evolution of a new Paradigm.*The Behavior Analyst.*19, 163-197.

Borg, W.R & Gall, M. D (1989).*Educational Research; An introduction (5thed)* white plains NY: Longman

Brunkalla, K. (2009). How to Increase Mathematical Creativity–an Experiment.*The Montana Mathematics Enthusiast.*6(1)

Cassanovas, M., Miralles, F., Gomez, M., & Garcia, R. (2010).Improving Creativity Results and its Implementation in Organization using Creative Technique through Experiential Learning Training.*Proceedings of the XXI ISPM conference* 2010, Bilbao.

Cook, T.D & Campbell (1979).*Quasi Experimentation: Design and Analysis Issues for Field Settings*. Newyork, NY: Rand McNally.

Cohen, L. & Manion, L. (1994).*Research Methods in Education.*Routledge Publishers.

Freiman, V. & Sriraman, B. (2007). Does Mathematics Gifted Education Need a working Philosophy of Creativity? *Mediterranean Journal for Research in Mathematics Education,* 6(1-2), 23-46

Gall, M.D., Borg, W.R., & Gall, J.P. (2007). *Educational Research: An Introduction.* White Plains NY: Longman.

Ganihar, N.N., &Wajiha, A.H. (2009).Factors Affecting Academic Achievement of IX Standard Students in Mathematics.*Edutracks,* 8(7) 25-33

Gill, E., Ben-Zvi, D., & Apel, N. (2007).What is hidden beyond the data? Helping young students to reason and argue about some wider universe. In D. Pratt & JAinley (Eds.), *Proceedings of the Fifth International Research Forum on Statistical Reasoning, Thinking and Literacy: Reasoning about StatisticalInference: Innovative Ways of Connecting Chance and Data* (pp. 1-26). UK:University of Warwick http://srtl.stat.auckland.ac.nz/srtl5/presentations

Githua, B.N &Njubi, J.N (2013). Effects of Practicing Mathematical Creativity Enhancing Learning/Teaching Strategy during Instruction on Secondary School Students Mathematics Achievement by Gender in Kenya's Nakuru Municipality, *Asian Journal of Management Science and Education* 2(2) 113-124

Imai, T. (2000).The Influence of Overcoming Fixation in Mathematics towards Divergent Thinking in Open-ended Mathematics Problems on Japanese Junior High School Students.*International Journal of Mathematical Education in Science and Technology.*31, 187-193

Jha, A. K. (2012). Creative Epistemology and Creative Pedagogy: *Implications for Creative Mathematics Education*: Paper presented in the 8th Global Conference on Creative Engagements: Thinking with Children at Mansfield College, Oxford , UK

Kadir, A. & Maker. (2011). Exploring the Relationship Between Mathematical Creativity and Mathematical Achievement. *Asia –Pacific Journal of Gifted and Talented Education.* 3(1), 34-45

Kim, H., Cho, S. & Ahn, D. (2003). Development of Mathematical Creative Problem Solving Ability Test for Identification of Gifted in Math. *Gifted Education International,* 18, 174-184

Kolb, A.Y., & Kolb, D.A (2008). Experiential Learning Theory: A Dynamic Holistic Approach to Management Learning. Education and Development in Armstrong, S.J. and Fukami, C. (eds).*Handbook of Management Learning Education and Development.*London Sage Publication.

Kolb, D. A. (1984) *Experiential Learning : Experience as a Source of Learning and Development* Eaglewood and Cliffs N. J USA : Prentice Hall.

Krutetskii, V. A. (1976). *The Psychology of Mathematical Abilities in School Children.* Chicago: University of Chicago Press.

Lamon, S. (2003). Beyond Constructivism: An Improved fitness Metaphor for the acquisition of Mathematical Knowledge. In R. Lesh& H. M. Doerr (Eds), *Beyond Constructivism*: Models and modelling Perspectives on Mathematics Problem Solving, Learning and Teaching. Mahwah. NJ: Lawrence Erlbaum and Associates.

Leikin, R. (2009). *Exploring Mathematical Creativity using Multiple solution tasks.* Rotterdam. The Netherlands: Sense Publishers.

Leikin, R., Berman, A., &Koichu, B. (2010).*Creativity inmathematics and the education ofgifted students.* Rotterdam:Sense Publishers

Liljedahl, P. &Sriraman, B. (2006).Musings on Mathematical Creativity, *FLM.*26(1), 17-19

Mann, E. L. (2005). Mathematical Creativity and School Mathematics: *Indicators of Mathematical Crreativity in Middle School Students.* Unpublished doctoral dissertation, University of Connecticut, Hartford.

Mann, E. L. (2006). Creativity: The Essence of Mathematics. *Journal for the Education of the Gifted,* 30(2), 236-260.

Meissner, H. (2000). *Creativity in Mathematics Education.* Paper presented at the meeting of the International

Congress on Mathematical Education, Tokyo.

National Council of Teachers of Mathematics (2000).*Principles and Standards for School Mathematics.*Reston, VA: NCTM

Naikakoji, K., Yamamoto, Y. &Ohira, M (1999).A framework that Supports Collective Creativity in Design Using Visual Images.In E. Edmonds & L. Candy (Eds).*Proceedings of the 3rd Conference on Creativity and Cognition,* pp. 166-173: ACM Press

Newsome, L.A., Wardlow, G.W., & Johnson D.M. (2005).*Effects of Lecture Versus Experiential Teaching Method on Cognitive Achievement, Retention and Attitudes Among High School Agriscience students.* National AAAE Research Conference 146-156.

Pooja, W. (2012).Achievement in Relation to Mathematical Creativity of Eighth Grade Students.*Indian Streams Research Journal.* 2(2) 1-7

Renzuli, J. S., Leppien, J. H. & Hays, T. S. (2000). *The Multiple Mean Model. A Practice Guide for Developing Different Curriculum*. Mansfield Center, CT: Creative Learning Press

Rogers, C.R. (1969). *Freedom to Learn.*Columbus , OH: Merrill

Runco, M. A. (1993). *Creativity as an Educational Objective for Disadvantaged Students* (RBDM 9306) Storrs, CT: The National Research Centre on the Gifted and Talented, University of Connecticut.

Sheffield, L. (2009). Developing Mathematical Creativity- Questions may be the Answer. In R. Leikin, A. Berman & B. Koichu (Eds), C*reativity in Mathematics and the Education of Gifted Students* (pp 87 - 100) Rotterdam: Sence Publishers

Sriraman, B. (2005). Are mathematical giftedness and mathematical creativity synonyms? A theoretical analysis of constructs.*Journal of Secondary Gifted Education*, 17(1), 20–36.

Stoyanova, E. &Ellerton, N. F. (1996).A Framework for Research into Students Problem Posing in School Mathematics.In P. Clarkson (Ed).*Technology in Mathematics Education:* Mathematics Education Research Group of Australia.