Chapter I

INTRODUCTION

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The spark of creativity is the force behind all scientific and technological advancement in human life. It is the key to success in the journey beyond boundaries and a creative mind uses the innate curiosity of an individual which is initiated by the intellectual disequilibrium and dissatisfaction on the facilities in the prevailing system. Creativity can be considered as a unique quality of mankind and is a complex and multi-faceted characteristic which involves the ability to produce original ideas and to perceive new relationships among unrelated things.

Creativity is basically a mental process, the ultimate production may be through loco motor systems, but the basic creative production is a result of the original mental processes resulting in original thinking. As a result of this original thinking, one is able to bring changes in the surroundings or in any material to produce a new item or arrangement of items. As Barron (1969) says, a combination of old ideas or products into new forms is also a reflection of creativity.

Creativity is thinking in divergent directions, promoting at most freedom of human thought and involves production of as many answers as possible to a given problem. It is different from discovery and inventions. Bronowski (1972) gives a clear distinction between them as, a fact is discovered, and a theory is invented whereas only a master piece is created. It can be an idea, property,
Creativity has a vital role in education which is developed through imagination and visualization. Education is a social process where an individual gets enabled to function according to the social expectations. As per Gandhian philosophy, education is a search within, a guiding force which goes deep into the inner world of humanity eliminating all errors and shortcomings and brings about purity and perfection of mankind, simultaneously enkindling the spirit of creative aesthetic efflorescence. In problematic situations, creative people respond and deal with it differently from stereotyped behaviors and mark his stamp of creativity. Creative individuals deal with social issues effectively by coming up with extra-ordinary choices and solutions in various spheres of life. Realizing the fact that creativity is an important element in education for the growth of the society, the educational system must accept responsibility for supporting and developing creativity among the young learners. Romey (1970) defined creativity as the ability to combine ideas, things, techniques or approaches in a new way. According to Guilford (1967) the ability to think divergently and to transfer information is essential to creativity and creative ideas must be fluent, flexible, capable of elaborating and redefining problems.

All are blessed with creative abilities, but in different domains. Creativity is domain specific and it cannot be stick onto any single field. It is
possible in all areas of human activity including the arts, science, at work, at play and in all other areas of daily life. Evolved knowledge is differentiated and specialized into various disciplines. A person may be creative or capable of divergent thinking to a greater degree in one situation or with one type of task than other. Creative master-pieces in arts and literature enrich human existence. Though they are obvious areas where creativity can be easily identified and encouraged, other fields like science, technology, mathematics, engineering etc. also need creative people. Creative insights in science illuminate people’s understanding of the world, where as creative inventions fuel our technological progress.

Mathematics is a subject which is related to almost all other subjects and certain amount of mathematical knowledge is essential to operate them. It is the language of science and is founded by simple yet powerful elements called numbers. When basic assumption and results are expressed in the form of mathematics formulae, the scientific and technological inventions got perfection beyond questioning (Sravan, 2015).

Mathematics has a prominent position in modern education as the science of space and quantity. Creativity is an integral part of Mathematics and hence the chief aim of teaching Mathematics is to develop those faculties which lead to the discovery and inventions. Mathematical Creativity is the ability to produce new solutions to problems or to produce relatively new associations. It is perceived differently by various experts in the field. Some
researchers approach it as a problem solving process whereas some approach it as a product. Mathematical Creativity is revealed through some complex mental powers such as the ability to recognize problems, to be flexible in thinking, to originate ideas or to develop products or to find new uses for old objects and materials.

Need and Significance of the Study

The area of Mathematical Creativity is a relatively less explored area in Mathematics education. Usual classroom teaching focuses on student achievement and in a Mathematics classroom, emphasis is given to logical, formal and conscious thinking. But a creative mathematical thinking is intuitive or unconscious.

Common men consider Mathematics as an inflexible subject which is formulaic and that highly demands mastery of skills and memorizing rules. In earlier days, Mathematics talent was assessed through speed and accuracy. In the pursuit of attaining speed and accuracy, a potential mathematical thinker is not getting ample time for reflection and incubation of ideas in his classroom. This period is an essential aspect of creativity which requires inquiry oriented, creativity enriched Mathematics curriculum and instruction. According to Whitecombe (1988) poverty in classroom experiences, appropriate, interest stimulating material and time to reflect deny creativity to develop among the potential creative learners.
In order to manifest Mathematical Creativity in classrooms, students should be given opportunity to tackle non-routine problems in the complexity and structure. The usual classroom practices and mathematics curricula do not encourage students to work on mathematical structure. Fisher (2004) emphasized the need for shifting the focus of education to the development of thinking and taking new initiation is essential so that the population will be equipped for a challenging world. Even for the existence and development of the subject of Mathematics, creative individuals in Mathematics are essential. The world is becoming complex and to cop up with the emerging trends and challenges, we need to develop creativity among the learners.

All are born with creativity and this potential can be nurtured to its maximum extent if given proper environment. Introducing new strategies in teaching can bring positive changes in the creativity of the learner (Kong, 2010; Chem Wei & Cheruiyet, 2013; Brannon, 2004; Khatib, 2011 & Gaylie, 2003). Henderson and Pingry (1953) suggested questioning, verbalization, hypothesis testing, constructing models, using heuristics, stressing relationships, and so on for developing Mathematical Creativity among learners. Methods of discovery, competitive games, and a variety of materials to build concrete images of important concepts are found to be generally successful in developing children’s Mathematical Creativity, but not all children need not benefit to the same degree.
In early stages of school education, Mathematics should not be rigid, it should be taught in an easy method which can arose interest in learning Mathematics. Early mathematical terminologies are very basic and related to daily activities. During the early stages, divergent thinking related to mathematics is to be developed. Flexibility and originality of thought to be encouraged by allowing more freedom in the class room and the fear factor is to be reduced. Haggard (1957) reported that when mathematically creative children of elementary school are getting threatened on their independence of thought and action, they tend to be more hostile and self-asserted. Creative talents are found to be more independent, and they dislike dull, routine work, but are stimulated by opportunities to discover things of their own. It will help for the development of other creative components in mathematics at higher stages.

A teacher should place high value on the child’s creative efforts and should know how and when to assist these efforts. Craft, Jeffrey and Leibling (2001) have highlighted the elements relevant to a framework for creativity as it must operate in the economic and political field, act as a possible vehicle for individual empowerment in institutions and be used for developing creativity.

Though many researchers report low correlation between general creativity and intelligence (Lanier, 1967), in certain studies Mathematical Creativity and Intelligence are found to have significant moderate correlation (Evans, 1965; Erhart, 1960 & Meconi, 1967). Leikin and Lev (2007) have
opined that in order to foster mathematical giftedness, teachers should present the basic concepts and permit the students to explore and discover the relations by themselves.

When the constraints of the class room, home and society are relaxed, creativity is encouraged; there is definite increase in creative thinking (Torrance 1950). Creating an environment conducive to active participation in the learning process and knowledge creation is to be ensured. The school should provide opportunities for discovery, experiment, self expression and exploration. The teacher should arrange a variety of learning experiences such as observation, project, field work, debate, etc.

Earlier traditional methods of teaching stressed rote memorization, development of intelligence and vocabulary in school education. In the recent past constructivism and learner centered approach conquered the education scenario in which learners construct knowledge in the social and cultural context. This method proposed that learning experiences should support multiple perspectives or interpretations of reality, knowledge construction, context rich, and experience –based activities so that students are expected to have excellent divergent thinking and high levels of creativity.

The usual classroom experiences are not sufficient for developing creativity among the learners and it is not practical to provide extra learning activities or learning hours along with the usual classroom activities, due to many reasons, especially the overloaded syllabus, poor infrastructure facilities,
over populated classroom, lack of interest, problems raised by the learners, etc. Hence to supplement the classroom learning, instructional packages can be used.

Completing the vast syllabus within the stipulated time will be a constraint for the teacher as well as the school administrators. This is the practical difficulty of constructivism which forces the teacher to follow a midway between traditional and constructivist approaches. The overloaded syllabus is a hindrance to the development of creativity and made lose its essence. In this scenario, learning modules and instructional packages help teachers to effectively manage time, vast syllabus and sustain interest among learners.

In a heterogeneous class, student management while giving learning activity is difficult. Training programs, special learning packages during free times, weekends, vacations, etc. is an option which can improve creativity. Modules are flexible so that implementation can be made by a variety of patterns. They are economical in use and can learn without disturbing the normal duties and responsibilities. It can be administered to single use, small group or large group.

Scheffield (2006) has listed major criteria of good tasks for encouraging Mathematical Creativity. According to him the task should contain challenging tasks that make students think deeply. It is expected to be rich enough to enable the children explore, reflect, extend and arrive at new areas keeping the core
standard of Mathematics. It has to use the previous knowledge of the learner and finally reaching at an unknown concept or principle. Students are expected to be engaged differently-orally, geometrically, algebraically etc. Real world experiences that require Mathematical manipulation and models, interesting to the learners and that help the learner to reflect and explore in groups are to be included. The question given must be open with more than one right answer and that develop mathematical sense.

The present study is an effort to develop a Package on Geometry of upper primary level with a view to foster Mathematical Creativity among the learners. Upper primary school students were selected as the participants for the implementation of the package; that is the age group from ten to thirteen. According to Piaget’s stages of intellectual development the age group from ten to thirteen is a transitional stage from concrete operational to formal operational. The children of this age group are able to think logically and intellectually in terms of interrelated principles. They can make use of inductive and deductive approaches in reasoning and arriving at conclusions (Piaget, 1926).

For this age group geometry is a familiar subject whereas algebra is just started. They are not deep into the algebraic concepts and operations. Geometry is a subject which lies very well with human daily activities. It’s a flexible subject and gives scope for various mathematical creative ideas, associations
and productions. Various geometric shapes and properties are familiar to them which help concretization of thinking.

**Statement of the Problem**

Though many techniques and strategies were developed for fostering Mathematical Creativity, an instructional package will help to support and supplement the classroom learning. The basic concepts on Geometry, presented in a non-routine way will help the students to comprehend the ideas more clearly and approach it in a novel manner with fluency and flexibility. Hence the present study is for constructing and validating a ‘Package on Geometry’ with a view to foster Mathematical Creativity of upper primary school students. The statement of the problem is “DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS”.

**Definition of Key Terms**

The key terms used in the statement of problem are operationally defined below.

**Development**

According to Oxford Dictionary (2003), development means bring or come to an active, visible or mature state. Development is the process of being developed.
In the present study development means construction and validation of a package on the basics of Geometry to foster Mathematical Creativity among upper primary school students.

**Package on Geometry**

The word package, as per Oxford dictionary (2003) is a set of proposals or items offered or agreed to be as a whole.

In the present study, package on Geometry means a set of eight modules on basics of Geometry, the content and activities of which are presented using multimedia. Module is a systematically arranged, self-contained and self-descriptive set of units prepared for a targeted population of learners for realizing specified instructional objectives.

**Mathematical Creativity**

According to Ervynck (1991) Mathematical Creativity is the ability to generate Mathematical objects which involves the generation of an idea to come up with a Mathematical problem within a Mathematical situation.

In the present study, Mathematical Creativity is operationally defined as the ability of an individual to produce variety, unique and original responses to the given mathematical question within the stipulated time and develop the idea into a meaningful and productive entity. Mathematical Creativity is the total of the scores on Fluency, Flexibility, Originality and Elaboration. Fluency is the ability to come up with many diverse ideas quickly, flexibility is the number of
different categories of responses, originality is the ability to produce rare or uncommon responses, remote associations or connections and elaboration is the amount of details associated with an idea.

**Upper Primary Students**

Children who are studying in fifth, sixth and seventh standards in schools managed by the Directorate of Public Instructions, Government of Kerala under Kerala Education Act and Rules are termed as upper primary students.

**Variables**

The study being an experimental one, a treatment variable is used. Here one group of subjects receives the treatment condition, that is the Package on Geometry and the other group does not. Hence the use of the Package on Geometry together with the usual classroom experiences and the usual classroom experiences alone are the two levels of the treatment.

In the present study Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration are the dependent variables. Mathematical Creativity is measured on the basis of scores obtained by the students in the test of Mathematical Creativity developed by the investigator.

Covariates considered in the present study are Intelligence and pre-test score on Mathematical Creativity whose influences are controlled using statistical methods in order to determine a the real effects of the independent
variable. Intelligence of the participants was measured using Raven’s Coloured Progressive Matrices (CPM).

**Objectives of the Study**

Following are the objectives of the study

1. To develop a ‘Package on Geometry’ of upper primary level to foster Mathematical Creativity among learners.

2. To find out the effectiveness of the ‘Package on Geometry’ on Mathematical Creativity and its components viz.
   
   a. Fluency
   b. Flexibility
   c. Originality
   d. Elaboration

**Hypotheses of the study**

Following hypotheses were formulated for testing the effectiveness of the ‘Package on Geometry’ developed by the investigator.

1. The post-test mean scores on Mathematical Creativity and its components of students using the Package on Geometry (experimental group) will be significantly higher than that of students not using the package (control group).
2. The post-test mean scores on Mathematical Creativity and its components will be significantly higher than the pre-test mean scores for students using the Package on Geometry.

3. The post-test mean scores on Mathematical Creativity and its components will not be significantly higher than that in pre-test for students who are not using the Package on Geometry.

4. The mean gain scores on Mathematical Creativity and its components of students using the Package on Geometry will be higher than that of students not using the package.

5. The mean difference in the gain scores on Mathematical Creativity of students using and not using the Package on Geometry will be significant when Intelligence scores measured through CPM and the pre-test scores on Mathematical Creativity are controlled statistically.

6. The mean scores on Mathematical Creativity in the pre-test and the successive tests will significantly differ for students using the Package on Geometry.

7. The Package on Geometry has a large effect on Mathematical Creativity among upper primary school students.

Methodology of the Study

Design of the Study

The present study follows a quasi-experimental design in which experimental and control groups are formed not by assigning individuals
randomly. One group of students was randomly taken as experimental group and the other as control group.

A pre-test on Mathematical Creativity and Raven’s Coloured Progressive Matrices were administered to both groups. Then the experimental group was exposed to the treatment where as the control group was not assigned with any special treatment other than usual classroom experiences. Post-test on Mathematical Creativity was administered to both groups after treatment. Formative tests on Mathematical Creativity were administered in the experimental group.

The experimental design adopted in the present study is diagrammed with symbols to indicate the arrangement of the variables and conditions. The design of the present study is

\[ O_1 \times O_2 \]
\[ O_3 \times C \times O_4 \]

Where, \( O_1 \) and \( O_3 \) are the pre-tests, \( O_2 \) and \( O_4 \) are the post tests, \( X \) is the experimental treatment and \( C \) is the controlled treatment.

**Participants**

Seventy upper primary school students (sixth and seventh standard) from CMGHSS, Kuttoor, Thrissur, Kerala were treated as the experimental group for testing the effect of the Package on Geometry on their Mathematical
Creativity. Seventy upper primary school students (sixth and seventh standard) from GVHSS, Machad, Thrissur, Kerala were treated as the control group.

**Instruments**

The major instruments used in the present study are as follows.

- Raven’s Coloured Progressive Matrices (CPM)
- Tests of Mathematical Creativity
- Package on Geometry
- Rating Scale on various aspects of the package

**Statistical Techniques**

Statistical techniques used for the present study are given below.

- Preliminary Analysis
- One tailed test of significance of difference between two means for large independent groups
- One-tailed test of significance of difference between two large dependent groups
- Two-tailed test of significance of difference between two means for large independent groups
- Analysis of Covariance (ANCOVA)
- ANOVA with Repeated Measures
- The effect size of the treatment variable
Scope and Limitations

The present study was intended to develop a ‘Package on Geometry’ and to explore its effectiveness on ‘Mathematical Creativity’. To realize the objectives of the study the investigator prepared tests on Mathematical Creativity and a package on geometry. The tests on Mathematical Creativity were used to assess the learner’s Mathematical Creativity and its components Fluency, Flexibility, Originality and Elaboration.

The major challenge in the study was designing appropriate learning materials and creative activities which are capable of fostering the creative talent of the learner. Further the level of language used for the presentation of package is adequate. Physical features like lay out, color, adequate pictures, diagrams, examples, printing, etc. were taken care of.

The package is of instructional mode which is divided into eight modules. Depending upon the content of each module, they are further divided into two or three sub modules. In order to ease the difficulty of mathematics a multi media approach is adopted. The content is transacted using various media such as text, graphics, animation, activities, etc. To develop interest in learning Mathematics, puzzles, games, workshops, activities etc. were included in the package wherever necessary.

The study was conducted on a sample of one hundred and forty upper primary school students from two schools. Two standards one from sixth and
The other from seventh were selected from each school. In order to control the effects of locality and type of school management, the experimental and control groups were selected from among the list of rural government schools. Also the two schools have almost the same level of academic and non-academic performance and the effects of intelligence and pre-test score on Mathematical Creativity were controlled statistically.

The package on geometry is expected to help the teachers and educational institutions to handle the issue of over loaded syllabus. The package can be given during weekends, vacations, or other free time. Otherwise it can be used among an interested group of students only.

The package on Geometry fosters not only Mathematical Creativity and its four components viz., Fluency, Flexibility, Originality and Elaboration, it is expected to be useful in developing interest in the subject for both category of students who love or fear mathematics.

It is expected that the findings of the study will help the curriculum planners and experts in educational field to include more provisions for the development of Mathematical Creativity. This novel strategy and new dimension of learning give a new meaning to mathematics education.

The investigator took maximum precautions to make the study as precise as possible and the experiment was conducted in an objective manner.
However some unavoidable limitations due to some extraneous variables may have intervened into the study. Some of them are

1. In the study the dependant variable, Mathematical Creativity and its four components viz., Fluency, Flexibility, Originality and Elaboration were measured using tests developed by the investigator which focus on product than the process.

2. The pre-test and post-test contain different items as same items can not be used for the same participants twice.

3. The successive tests on Mathematical Creativity are used as formative measure and hence the tests were not standardized.

4. The study was conducted in the schools of Thrissur district only, not state wide.

5. The study has been conducted on sixth and seventh standard students of two schools only.

6. The concept of Mathematical Creativity was taken as per the definition of Ervynck (1991), but the problem solving aspect suggested by him was excluded.

7. The study has not used any control over the intervening variables other than intelligence and pre-test score on Mathematical Creativity like interest, attitude, anxiety etc.

Even though the Package on Geometry was planned to implement as a vacation activity, due to practical difficulties it was implemented as regular
morning sessions of regular working days. There occurred some limitations; however the result derived from the present study is expected to be valuable enough for further research and innovation.

**Organization of the report**

The report has been presented in 5 chapters

**Chapter 1:**

This chapter presents a brief introduction to the problem, its need and significance, statement of the problem, definition of key terms, variables, objectives, hypotheses, methodology, scope and limitations of the study.

**Chapter 2:**

This chapter presents the conceptual overview of the concerned variables and review of the related studies.

**Chapter 3:**

This chapter gives an account of the methodology in detail used in the present study. It contains design of the study, variables, participants, description of instruments employed for data collection, data collection procedure, scoring and statistical techniques used.
Chapter 4:

This chapter describes the preliminary analysis, analysis part of the study as per the objectives and their results and discussions.

Chapter 5:

This chapter presents a summary of the study, major findings, tenability of hypotheses, conclusions, educational implications of the study and suggestions for further research in this area.