DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS

Thesis

Submitted for the Degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

By

JINU M. K.

Supervised by

Dr. K.VIJAYAKUMARI
Associate Professor

FAROOK TRAINING COLLEGE
RESEARCH CENTRE IN EDUCATION
UNIVERSITY OF CALICUT
2018

DECLARATION

I, Jinu M. K., do hereby declare that this thesis entitled as "**DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS"** is a genuine record of the research work done by me under the supervision of Dr. K. Vijayakumari, Associate Professor, Farook Training College; and that no part of the thesis has been presented earlier for the award of any Degree, Diploma or Associateship in any other University.

Farook Training College
03 -12- 2018 **Jinu M. K.**

Dr. K. VIJAYAKUMARI
Associate Professor
Farook Training College, Calicut

CERTIFICATE

This is to certify that the thesis entitled "**DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS"** is an authentic record of research work carried out by JINU M. K., for the degree of Doctor of Philosophy in Education, University of Calicut, under my supervision and guidance and that no part thereof has been presented before any other Degree, Diploma, or Associateship in any other University.

Contents in the hardcopy and softcopy are the same.

Farook Training College
03 -12- 2018

Dr. K. Vijayakumari
(Research Supervisor)

Acknowledgements

The investigator wishes to place on record her deep sense of gratitude and sincere thanks to all the people who have directly or indirectly helped her in designing and completing this study.

At the very outset the investigator bows to the almighty God for the grace and blessings always bestowed on her, devoid of whom she could not have successfully complete the task.

The investigator underlines her deep sense of gratitude and profound indebtedness which undoubtedly owes to her supervising teacher, ***Dr. K. Vijayakumari,*** *Associate professor, Farook Training College. She has been a spring of corrective suggestions and valuable advice which has been boosted the investigator from the beginning to the end. The successful completion of this work was the result of her scholarly and expert guidance.*

The investigator expresses her thanks to ***Dr. C. A. Jawahar,*** *Principal, Farook Training College, for providing all necessary facilities and encouragement to conduct the study. The investigator would like to express her gratitude to* ***A. Faziluddin****, former Principal, Farook Training College also.*

The investigator wishes to express her gratitude to ***Dr. V. Sumangala,*** *Former HoD & Professor in Education, University of Calicut for giving permission to use 'Test of Mathematical Creativity' prepared by her for the standardization of the tool for the present study and for valuable suggestions and instructions in the development of 'Tests of Mathematical Creativity' and 'Package on Geometry'. The investigator wishes to express her sincere gratitude to* ***P. R. Mercy****, Principal, DIET Kottayam (formerly Senior lecturer DIET Thrissur) for valuable suggestions and instructions in the development of 'Tests of Mathematical Creativity' and 'Package on Geometry'.*

The investigator is grateful to ***Dr. N. S. Mumthas****, Associate Professor, Farook Training College for her valuable suggestions and instructions during various stages of the study. The investigator would like to express sincere thanks to* ***Dr. K. Manikandan****, Professor, Department of Psychology, University of Calicut for valuable suggestions and instructions during the study.*

The investigator expresses her thanks to the Heads, Teachers and Students of C. M. G. H. S. S. Kuttoor and G. V. H. S. S. Machad, for their cooperation and help for data collection of the study. The investigator takes this *opportunity for expressing her deep sense of gratitude to* ***K. S. Muraleedharan****, (HSA), C. M. G. H. S. S. Kuttoor, for valuable assistance in arranging adequate facilities during the data collection. The investigator expresses her thanks to the Heads, Teachers and Students of GHSS, Villadom; Nirmala HSS, Ayyanthol; St. Thomas HSS, Thiroor; GHSS, Punkunnam; Marymatha HSS, Panthalampadom; GHSS, Kunissery; GHSS, Kottayi and PKHS, Manjapra for their cooperation and help for the study.*

The investigator would like to express thanks to ***Majison****, HSA, St. Thomas HSS, Thrissur and* ***Dendish****, HSA, CMS HSS, Thrissur for the technical assistance in module preparation. The investigator wishes to express her deep sense of gratitude to her sister* ***M. K. Jeena****, P. A., India Post, Northern Kerala Division for her unending support, and assistance at various stages of the research work.*

The investigator would like to express thanks to the librarian ***M. Sabira (****FTC), Assistant librarian and other library staffs of Farook Training College Library and CHMK Library, Calicut University.*

The investigator would like to express thanks to all teaching and non teaching staffs of Farook Training College for their support and encouragement during the study.

The investigator acknowledges the immense moral support and encouragement received from her family and friends who have been a constant source of inspiration for the study especially ***Shahidali, Saritha, Jasna, Binita, Blessytha, Prasheeda, Shimi and Vijesh.*** *The investigator profoundly thank to Educare Xerox, Thrissur; Bina Photostat, Calicut University; Bhavana Photostat, Thrissur, Big Sphere Photostat, Thrissur and Sugathan's Press, Farook College for DTP, Printing and binding the Thesis.*

Farook Training College

Date : 03-12-2018 ***JINU M. K.***

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

JINU M. K. “DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS”. THESIS. RESEARCH CENTRE IN EDUCATION, FAROOK TRAINING COLLEGE, UNIVERSITY OF CALICUT, 2018.

Chapter I

INTRODUCTION

- ***Need and Significance of the Study***
- ***Statement of the Problem***
- ***Definition of Key Terms***
- ***Variables***
- ***Objectives of the Study***
- ***Hypotheses of the Study***
- ***Methodology of the Study***
- ***Scope and Limitations***
- ***Organization of the Report***

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, theorem, product, instrument, piece of art, musical composition or a rhythmic poem.

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 class room. 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 class room 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 mid-way 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 cop 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 X O_2

O_3 C 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.

JINU M. K. “DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS”. THESIS. RESEARCH CENTRE IN EDUCATION, FAROOK TRAINING COLLEGE, UNIVERSITY OF CALICUT, 2018.

Chapter II

REVIEW OF RELATED LITERATURE

- ***Theoretical Overview***
- ***Review of Related Studies***

REVIEW OF RELATED LITERATURE

This chapter describes the underpinning theories of the variables under study and tries to provide a better understanding of the concept of creativity. An attempt was made to trace the origin of variables and its development with special emphasis on current status. In this chapter the investigator presents the theoretical outline of Creativity and related studies. These are presented under two sections viz.,

- Theoretical overview of creativity
- Review of related studies on creativity
- Theoretical overview of mathematical creativity
- Review of related studies on mathematical creativity

Theoretical overview of Creativity

Creativity is the cognitive ability to think divergently and produce a number of flexible and original responses to specified stimulus. It helps human beings to solve complicated problems in different walks of life. There are numerous definitions to creativity. Some thinkers consider creativity as a product, a process or a personal trait. Since there is no perfect definition of creativity, various definitions help to formulate a holistic view of it. Some widely accepted definitions of creativity are given.

Historic Perspective on Creativity

In the primitive society, creativity was considered as a divine quality which was gifted by God to human beings. Creative people in ancient world thus enjoyed privileges. In those days, it was considered as luck and confined to a few individuals or a group in relation to caste, creed and colour. It was not considered as universally distributed.

Another ancient concept of creativity was that it is a natural endowment and innate capacity. People possessed inborn creative talents and expressed it without any learning or training. Highly talented mathematicians, scientists, musicians, poets, etc. were considered creative in various fields.

The concept of environmentally acquirable creativity evolved later and it was considered as an ability which can be nurtured. Being a natural endowment it needs stimulation and nourishment through positive, open and flexible environment.

Definition of Creativity

The word ‘creativity’ was originated from an Indo-European word ‘kere’ which means ‘to create something’. Thus the epistemological meaning of the word ‘creativity’ is ‘to develop something new’. Creativity is a complicated cognitive trait of human beings. Thinkers develop varying view points about it and hence various view points were evolved.

The concept of creativity was first recognized by Galton (1870) in his book ‘Men of Genius’. According to him, creativity is a cognitive ability of human beings to think divergently and produce a number of original and flexible responses to a set of specified stimulus.

According to Thurstone (1952) the novel ideas of an individual leads to solutions. If he reaches to the solution in a sudden closure as an instinct, he is said to be creative. In his opinion an individual having novelty of ideas which lead to productive solutions are said to be creative.

Newell, Shaw and Simon (1962) define creativity as an unconventional thinking which was initially vague and undefined. It leads to the formulation of a clear solution which is highly motivated and persistent. This type of unconventional thinking is termed as creativity. According to them, the thinker and his culture have great value. Since the task involved is of great intensity, the product has novelty.

According to Torrance (1960) creative thinking is “the process of sensing gap or disturbing, missing elements, forming ideas or hypotheses concerning them; testing these hypotheses; and communicating the results, possibly modifying and retesting hypotheses”. The more accepted concept of creativity is that of Torrance and according to him, central features of creativity are fluency, flexibility originality and elaboration.

In the opinion of Ausubel (1963) creativity is a generalized constellation of intellectual abilities, personality variables and problem solving traits. Wallach and Kogan (1965) also consider creativity as an intellectual quality of man. According to them the characteristic of creativity is to produce more and more associations which are unique.

Dictionary of education by Good (1972) defines creativity as a quality thought to be composed of a broad continuum, upon which all members of population may be placed in different degrees and the factors of creativity are tentatively described as associative and ideational fluency, originality, adaptive and spontaneous flexibility and the ability to make logical evaluation.

According to Levin (1978) creativity is a special form of thinking. It is the ability to discover new solutions to the existing problems; otherwise it can be producing new ideas, inventions or works of art.

Sternberg (1988) defines creativity as a process which results into a novel work. It is accepted as a tenable and useful trait. According to him, the novel work is satisfying at some point of time to a group of people.

According to Parnes (1992) creativity is the process of thinking and responding. It is connected with our previous experience. It involves responding to stimuli such as objects, symbols, ideas, people, situations, etc. In his opinion all the thinking process should be result-oriented and it must end up with generating at least one unique combination.

The details of various definitions of Creativity put forward by various thinkers are listed in table 1.

Table 1

Details of Various Definitions of Creativity

Proponent	**Year**	**Definition of Creativity**
Galton	1870	Divergent cognitive ability of man to think and produce a number of flexible and original responses to a specified stimulus.
Thurstone	1952	A creative individual with novel ideas can evolve productive solutions.
Newell, Shaw and Simon	1962	Creativity is an unconventional thinking leading to the formulation of persistent solution.
Torrance	1962	The process of sensing gap or disturbing , missing elements, forming ideas or hypotheses concerning them; testing these hypotheses; and communicating the results, possibly modifying and retesting hypotheses
Ausubel	1963	Creativity is a generalized constellation of intellectual abilities, personality variables and problem solving traits.
Wallach and Kogan	1965	Creativity is an intellectual quality of human beings to produce more and more unique associations.
Good	1972	Quality thought to be composed of a broad continuum, upon which all members of population may be placed in different degrees.
Levin	1978	Creativity is a special form of thinking which results into the discovery of new solutions to existing problems or to produce new ideas, inventions or works of art
Sternberg	1988	Creativity is a process which results into a novel work. It is accepted as a tenable and useful trait
Parnes	1992	A process of thinking and responding which is connected with our previous experience. It involves responding to stimuli such as objects, symbols, ideas, people, situations, etc. and generating at least one unique combination.

Approaches to Creativity

Various theories on creativity utilized various approaches to creativity and these approaches give a vision of the phenomenon of creativity.

Person Approach

The person approach was put forward by Alleck (1937). The fundamental idea behind this approach is that the creativity can be easily identified in terms of the abilities and functions of creative individuals. They are performance on a test of creativity, evaluation of the product or idea created by person, measuring person's self-actualization, and usefulness or social acceptance of the product or idea. Highly creative persons are usually differentiated from low creative in terms of creative qualities. People are creative in particular domains, but they may share common traits. The creative abilities mentioned by Person Approach of Alleck are diagrammatized in figure 1.

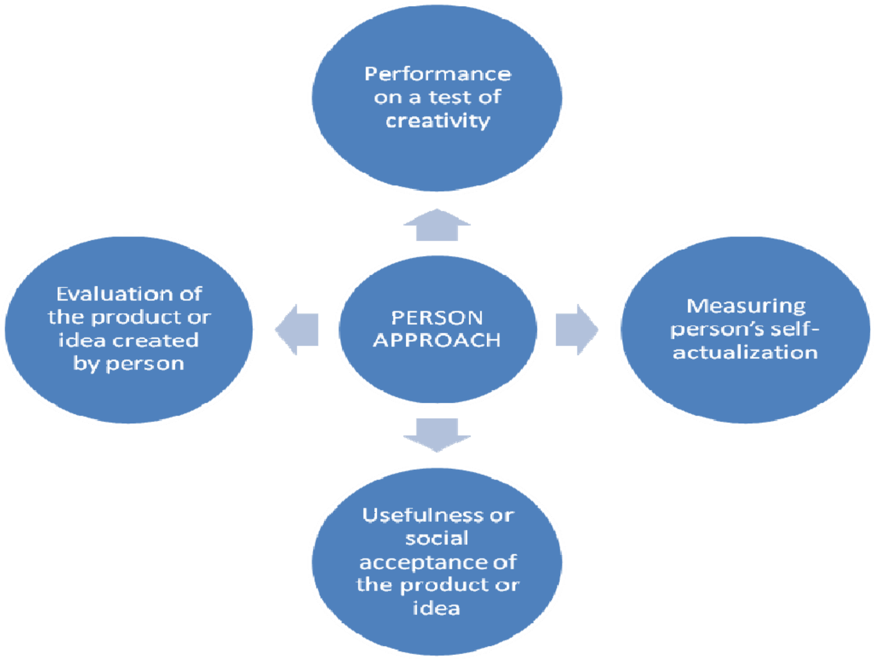


Figure 1. Four abilities mentioned by Person Approach of Alleck

Product approach

Mackinnon (1962) has given five criteria or requirements to decide the creativeness of a product. The first step of decisive criterion mentioned by him is that product should have originality and novelty, then the product should serve to solve the problem, useful and possess adaptability to reality as per goals. The product should have aesthetically pleasant experience, should be elaborated, developed to the full and at last it should be able to communicate to others. In figure 2, the decisive criterion mentioned by Product Approach of Mackinnon is shown.

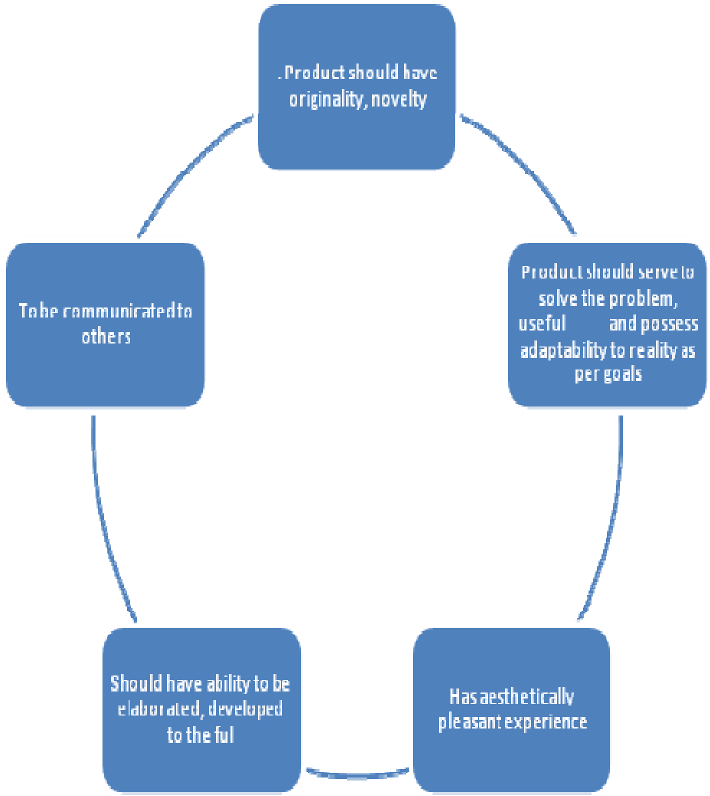


Figure 2. Five decisive criterion mentioned by the Product Approach of Mackinnon

Process approach

Mansfield and Buse (1981) addressed the creative process in science fields. There are five stages in the process of creativity as selection of the problem sensitively, extended efforts to solve the problem, deciding and using experimental, methodological and cognitive skills, changing the decisions according to the hypotheses and the verification and elaboration needs repeating the experiment. The Creative Process approach as proposed by Mansfield and Buse with its stages is given in figure 3.

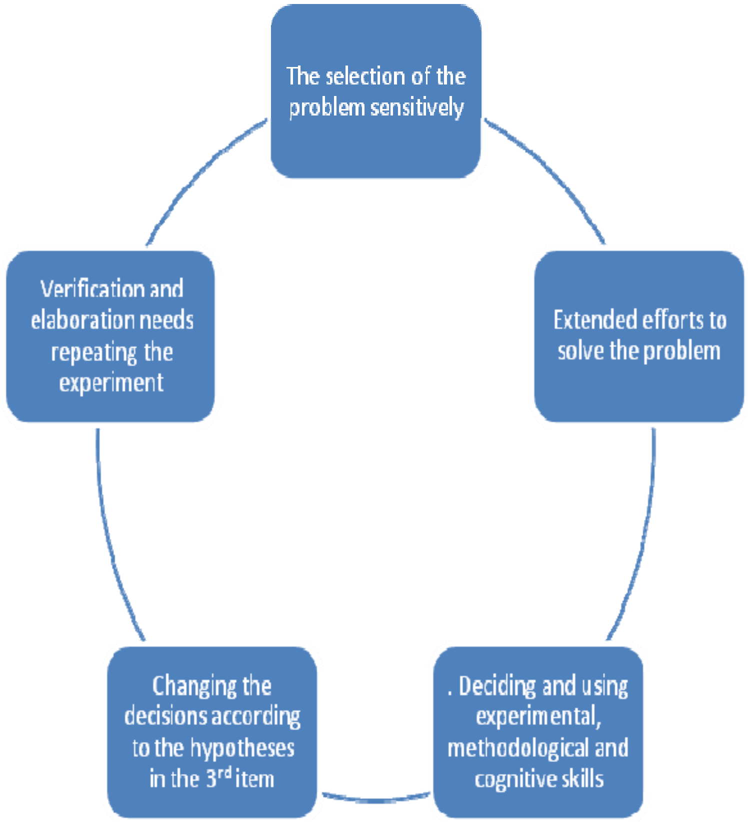


Figure 3. Stages of Creative Process by Mansfield and Buse

The approach of associationism

An approach of ‘associationism’ was explained by Mednick (1964) as the chain of stimulus response connection. According to him creativity involves formulation of association between stimulus and response which are characterized by the fact that the elements linked together are not associated normally. When a problem is initiated in a new situation, a succession of previously learned responses is evolved. According to him there is no fundamental difference between the higher mental function to that of the lower. The process of thinking and finding a solution to a problem may be trial and error, logical or a creative thought. The process of creativity to produce new solutions will be more remote as the combinatory elements are mutually remote.

Divergent thinking approach

Guilford (1967) drew a distinction between convergent and divergent thinking. According to him convergent thinking aims for a single correct solution to a problem. He defined divergent production as "a set of factors of intellectual ability that pertain primarily to information retrieval and with their tests which call for a number of varied responses to each test item". Divergent thinking is the generation of multiple responses which are equally acceptable to a given problem. He identified the properties of divergent creative thinking abilities viz., fluency, flexibility, originality and elaboration.

On the basis of structure of intellect model, he explained the construct of creativity. Guilford's divergent thinking abilities are distinguished into three categories viz., figural, symbolic, and semantic. The three categories are divided into six kinds of products viz., units, classes, relations, systems transformations and implications. In divergent production, units, classes, systems and implications have all the three categories figural, symbolic, and semantic. However, relations have only symbolic and semantic factors whereas transformations have only figural and semantic factors. Details of categories and factors in divergent production proposed by Guilford are given as table 2.

Table 2

Details of Categories and Factors in Divergent Production

No.	Category / Product	Figural	Symbolic	Semantic
1	Units	Yes	Yes	Yes
2	Classes	Yes	Yes	Yes
3	Relations	No	Yes	Yes
4	Systems	Yes	Yes	Yes
5	Transformations	Yes	No	Yes
6	Implications	Yes	Yes	Yes

Psycho dynamic approaches

The psycho dynamic approach was considered as the first twentieth-century major theoretical approach to the study of creativity. It mostly relied on case studies of environment creators. Freud (1976) proposed that the basic idea of psycho dynamic approach was that creativity arises from the tension between conscious reality and unconscious drives. In order to express an individual's unconscious wishes concerning power, richness, fame, honor, or love, there exists a tension between conscious reality and unconscious drives.

Early twentieth-century scientific schools of psychology- such as structuralism, functionalism and behaviorism did not make any significant contribution to the study of creativity. The psycho dynamic school was the only school which offered some insights into the study of creativity. However it was not at the center of the emerging scientific psychology.

Cognitive approach

According to Haddon and Lytton (1968) divergent thinking has provided a new insight into cognitive functioning. The process of thought involved in divergent thinking scan all stored information, search for possible solutions and one's thought flows in diversified direction which help an individual to explore new and untested direction. In creative thinking also the matter is generated from the memory storage but there are possibilities to solve a problem by linking new connections or by adopting revised forms, which ultimately leads to the production of something new and unique which is considered to be an important condition for creative work. The structure of Intellect Divergent Production Test Battery captures an individual's potential of divergent production in several areas, involving those of semantic systems; figural systems and symbolic units which involved in divergent production ability test.

Approach of novel scientific process

According to Moravcsik (1981) scientific creativity is the attainment of new and novel steps in realizing the objectives of science. Scientific creativity can manifest itself "in the conception of new ideas contributing to Scientific knowledge itself, in the formation of new theories of science, in devising new experiments to probe nature’s law, in the development of scientific ideas applied to particular domains of practical interest, in the realization of new organizational features of scientific research and of scientific community, in the novel implementation of plans and blueprints for scientific activities , in trail-blazing undertakings to transmit the scientific outlook into the public mind, and in many other realms”. He explained scientific creativity by saying- “it can explain itself in comprehending the new ideas and concepts added to scientific knowledge, in formulating new theories in science, finding new experiments, preventing the natural laws, in recognizing new regulatory properties of scientific research and scientific group, in giving the scientific activity plans and projects originality and many other ideas”.

Pragmatic approach

De Bono was the foremost proponent of the pragmatic approach whose work on lateral thinking and other aspects of creativity had commercial success (De Bono, 1992). ‘Thinking hats’ was a tool in order to stimulate seeing things from different points of view. That is the individuals metaphorically wear different hats; such as a white hat for data based thinking, a red hat for intuitive thinking, a black hat for critical thinking, and a green hat for generative thinking. He was more concerned of practice than that of theory.

Mystical approach

The study of creativity has always been associated with mystical beliefs and divine interventions. The creative person was viewed as a divine being filled with the inspiration. The individual would then pour out the inspired ideas, forming another world product (Sternberg & Lubart, 1995). According to the Greek mythology, the invocation of muse is a source of inspiration for all the poets especially to create choral songs and epic poems. Sometimes mystical sources have been suggested for literary creations.

Psychometric approach

According to Plucker and Renzulli (1999) several distinct approaches are used to examine creative phenomenon, a majority of work dealing with creativity relies on psychometric methods-the direct measurement of creativity or its perceived correlates in individuals. Psychometric study of creativity is beneficial for measuring creativity, analyzing its development, characteristics, strengths and weakness. Psychometric approach is traditionally considered as the formal starting date of scientific creativity research. This method advocates that creativity could be studied with psychometric approach in everyday subjects, using paper and pencil tasks.

Various approaches on creativity put forwarded, its proponents and year are listed below in table 3.

Table 3

Details of Various Approaches of Creativity

Proponents	Year	Approaches of Creativity
Alleck	1937	Person Approach
Mackinnon	1962	Product Approach
Mednick	1964	Associationism
Guilford	1967	Divergent Thinking Approach
Haddon and Lytton	1968	Cognitive Functioning Approach
Freud	1976	Psycho Dynamic Approaches,
Moravcsik	1981	Process Approach
Mansfield and Buse	1981	Process Approach
De Bono	1992	Pragmatic Approach
Sternberg & Lubert	1995	Mystical Approach
Plucker and Renzulli	1999	Psychometric Approach

Theories on Creativity

Each theory on creativity views it from a particular dimension and none of them provide a complete picture of it. They have their own stand for explaining creativity either through the process approach or the product approach. Hence each perception is only a fragment of the holistic perception. By integrating various views of different theories, a meaningful picture of creativity can be attained.

Conceptual blending theory

Koestler (1964) introduced the concept of bisociation. Creativity arises as a result of the intersection of two quiet different frames of reference which is termed as bisociation. This idea was later developed into conceptual blending. Various converging approaches in cognitive science deal with metaphor, analogy and structure mapping. Under the label conceptual blending, a new integrative approach to the study of creativity in science, art and humor has been emerged. According to him there are three types of creative individuals- the artist, the sage and the jester. The artist creates beauty or challenge, the sage creates ideas or solutions whereas the jester creates humor. This trinity theory believes that all the three types of creative individuals are essential for the smooth going of a balanced society. Classification of creative individual characteristics proposed by Conceptual blending theory of Koestler is given as figure 4.

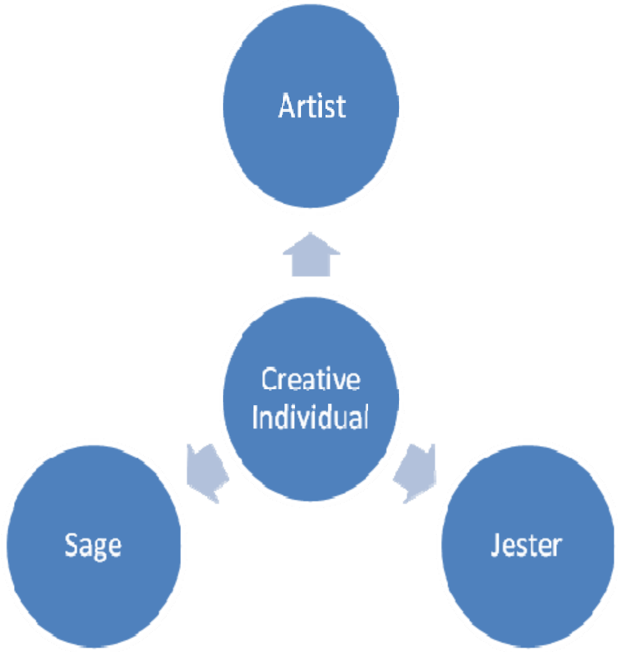


Figure 4: Classification of creative individual characteristics proposed by Conceptual Blending Theory

Geneplore theory

"Geneplore" theory was proposed by Finke (1992) according to which creativity takes place in two phases- a generative phase and an exploratory phase. An individual constructs mental representations called pre-inventive structures in the generative phase and those structures are used to come up with creative ideas in the exploratory phase. Some evidence shows that when people use their imagination to develop new ideas, those ideas was heavily structured in predictable ways by the properties of existing categories and concepts. Various Phases of Creativity and their description proposed by Geneplore theory is given in table 4.

Table 4

Various Phases of Creativity Proposed by Geneplore Theory

No.	Phases	Description of the Phase
1	Generative Phase	An individual constructs mental representations called pre-inventive structures
2	Exploratory Phase	Pre-inventive structures are used to come up with creative ideas

Honing theory

Honing theory, developed by Gabora (1997) proposes that creativity arises due to a world view having the self-organizing and self mending nature. By the way of creative process an individual hones and formulates an integrated view of the world around. Honing theory places equal emphasis on the externally visible creative outcome and the internal cognitive restructuring. According to this theory, the internal cognitive restructuring is brought about by the creative process. It focuses on not just restructuring as it pertains to the conception of the task, but to the world view as a whole. When faced with a creatively demanding task, there is an interaction between the conception of the task and the world view. The conception of the task changes through interaction with the world view, and the world view changes through interaction with the task. This interaction is reiterated until the task is complete. In this interaction the task is conceived of differently and the world view is subtly or drastically transformed. Creative process reflects the natural tendency of a world view in order to resolve dissonance is another distinguishing feature of honing theory. Also, it seeks internal consistency amongst its components viz., ideas, attitudes, or bits of knowledge.

Incubation theory

Ward (2003) proposed the term incubation which is a temporary break from creative problem solving that can result an insight. The empirical research aiming at the concept of incubation mentions about a period of interruption or rest. He lists various hypotheses which facilitate the explanation of incubation. Some empirical evidences show that incubation aids creative problem solving which involves elimination of misleading and confusing clues. Absence of incubation may lead the problem solver to become fixated on inappropriate strategies of solving the problem. This theory is a contradiction to other theories on creativity as it believes that creative solutions to problems arise mysteriously from the unconscious mind.

The explicit-implicit interaction (EII) theory

The Explicit-Implicit interaction Theory of creativity was proposed by Helie and Sun (2010). It is a unified framework for understanding creativity in problem solving. This theory is an attempt for providing a more unified explanation of relevant phenomena. This work represents an initial step in the development of process-based theories of creativity encompassing incubation, insight, and various other related phenomena.

Various theories of Creativity with the proponents and year are listed in table 5.

Table 5

Details of Various Theories of Creativity

Proponent	**Year**	**Theory of Creativity**
Koestler	1964	Conceptual Blending Theory
Finke	1992	Gene-plore Theory
Gabora	1997	Honing Theory
Ward	2003	Incubation Theory
Helie and Sun	2010	Explicit-Implicit nteraction Theory

Models of Creativity

The models represent a piece of the theory of creativity that is the how of creative thinking process and how creative ideas emerge over time.

Arieti (1976) in his book ‘Creativity: The Magical Synthesis’ described about models of the creative thinking. There he proposed eight models of the creative thinking process and later on additional models have been added. However some experts dismiss the notion that creativity can be described as a sequence of steps in a model. Gestalt philosophers like Wertheimer (1945) mentioned that the process of creative thinking is an integrated line of thought that does not lend itself to the segmentation implied by the steps of a model. Vinacke (1952) also was of the opinion that creative thinking in the arts does not follow a model of creativity with distinct steps and criterion.

Wallas model of the process of creativity

Wallas (1926) was considered as the proponent of one of the early models of the creative process. According to him, the process of creativity is a combination of ideas that are not generally associated together. He proposed that creative thinking proceeds through the four phases viz., preparation, incubation, illumination and verification. The four phases involved in the process of creativity and their description proposed by Wallas are listed in table 6.

Table 6

The Phases Involved in Wallas Model of the Process of Creativity

No:	Phases	Description
Phase1	Preparation	Definition of issue, observation, and study
Phase2	Incubation	Laying the issue aside for a time
Phase3	Illumination	The moment when a new idea finally emergence
Phase4	Verification	Checking it out

Rossman's analytical model of creativity

While some models make it appear that creativity is a somewhat magical process, the predominant models lean more toward the theory that novel ideas emerge from the conscious effort to balance analysis and I magination. For example, Rossman (1931) examined the creative process via questionnaires completed by 710 inventors and expanded Wallas' original four steps to seven.

The steps involved in Rossman's creativity model are observation of a need or difficulty, analysis of the need, a survey of all available information, formulation of all objective solutions, a critical analysis of these solutions for their advantages and disadvantages, the birth of the new idea – the invention and experimentation to test out the most promising solution, and the selection and perfection of the final embodiment. Rossman's creativity model and steps involved are given in figure 5.

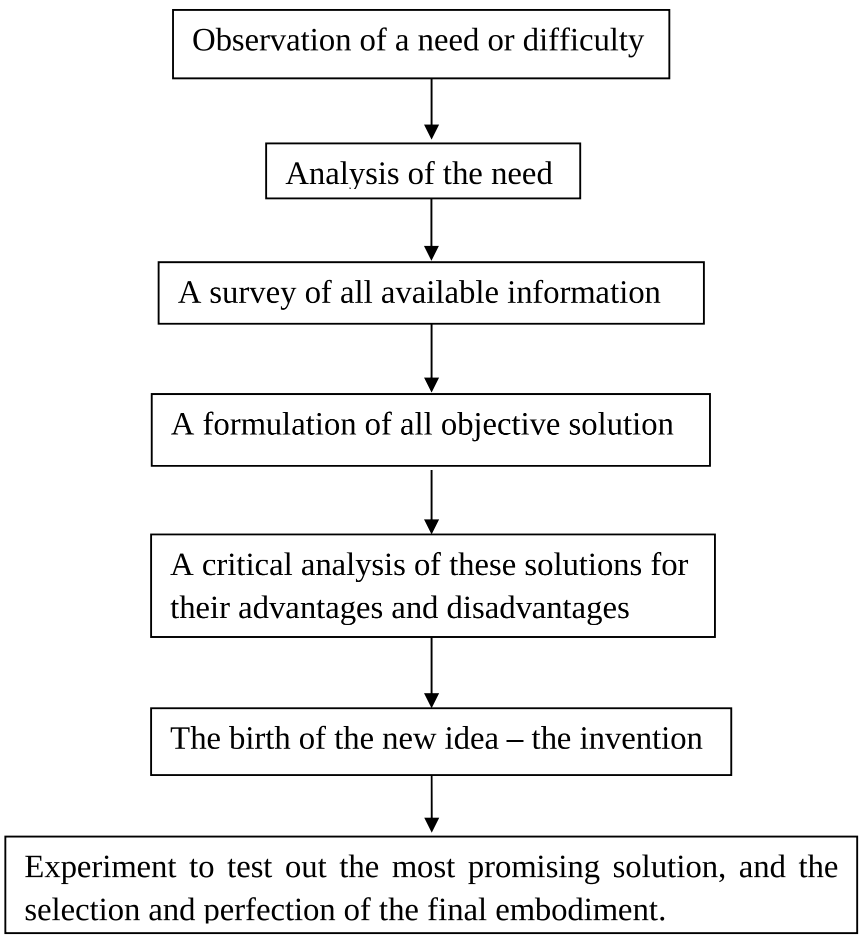


Figure 5. Rossman's creativity model

The structure of intellect model

Guilford (2007) introduced a model to explain the construct of creativity based on factor analysis which provided a systematic theoretical foundation to the study of creativity. This model describes every human mental process or intellectual activity in terms of three different basic dimensions or parameters viz., operations, contents and products. The dimension of the act of thinking is divided into five kinds of operations viz., evaluation, convergent thinking, divergent thinking, memory and cognition. The product or the ideas one comes up with are divided into six viz., units, classes, relations, systems, transformations and implications. The contents or the terms in which one think such as words or symbols can be divided into five viz., visual, auditory, symbolic, sematic and behavioral. All mental abilities are conceptualized within a three dimensional framework.

The three dimensional Model of Structure Of Intellect (SOI) is shown in figure 6.

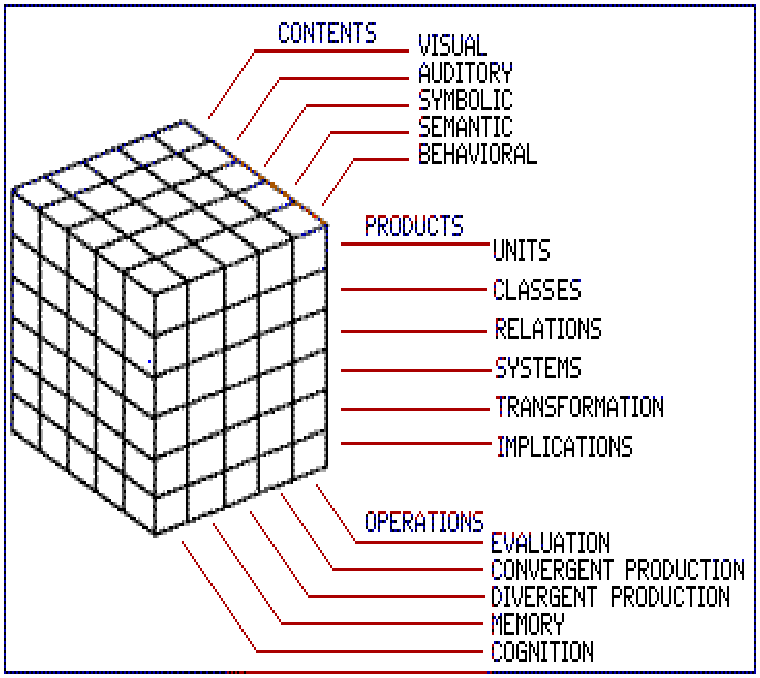


Figure 6. Structure of Intellect Model of Guilford

Osborn's seven step model for creative thinking

Osborn (1953) the developer of brainstorming as an efficient tool for development of creativity, adopted a theory of balance between analysis and imagination. The seven steps of creative thinking proposed by him are orientation, preparation, analysis, ideation, incubation, synthesis and evaluation. Details of Osborn's Seven-step Model for Creative Thinking is given in table 7.

Table 7

Osborn's Seven-step Model for Creative Thinking

No:	Step	Description
1	Orientation	Pointing up the problem
2	Preparation	Gathering pertinent data
3	Analysis	Breaking down the relevant material
4	Ideation	Piling up alternatives by way of ideas
5	Incubation	Letting up, to invite illumination
6	Synthesis	Putting the pieces together
7	Evaluation	Judging the resulting ideas

Koberg and Bagnall's Universal Traveler Model

In their book 'The Universal Traveller', Koberg and Bagnall (1981) mentioned about a balanced model. Ideation, the traditional focus of creative thinking tools like brain storming, is proceded by deliberating an analytical thinking. Koberg and Bagnall gave a great deal of importance to the acceptance of situation as an individual challenge. The steps involved in the Universal Traveler Model proposed by Koberg and Bagnall is given in figure 7.

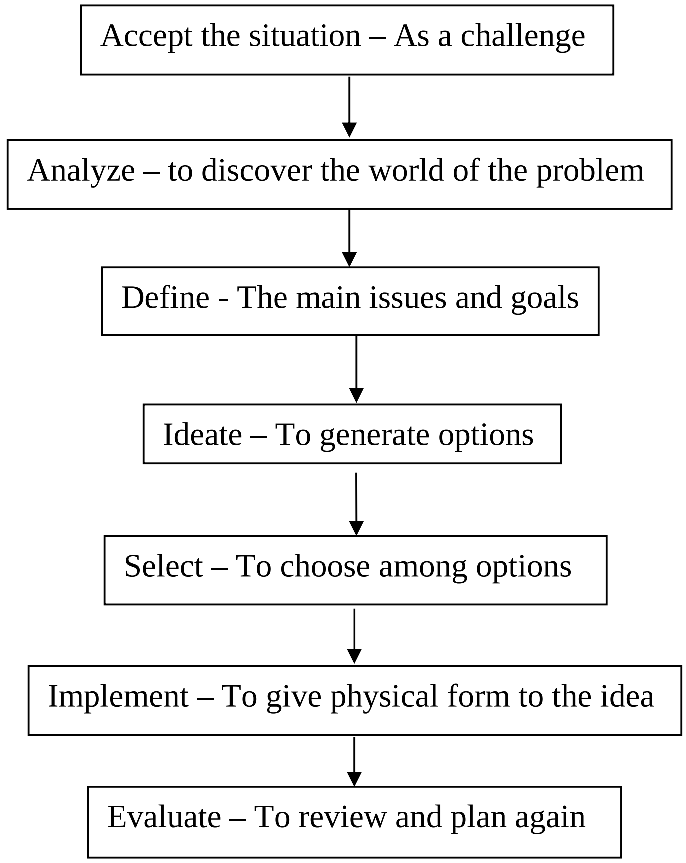


Figure 7. Steps Involved in Universal Traveler Model of Koberg and Bagnall

Model for creative strategic planning

Bandrowski (1985) has devised a model for creative strategic planning which emphasizes on judgment. The need for applying specific creative skills in insight development, creative leaps, and creative contingency planning are also stressed in the model. The Model for creative strategic planning involves analysis, creativity, judgment, planning and action. Analysis involves standard planning and insight development, whereas creativity involves creative leaps and strategic connections. Judgment involves concept building and critical judgment whereas planning involves action planning and creative contingency planning. The last step proposed by Bandrowski model for creative strategic planning is action which involves flexible implementation and monitoring of the results. The model for creative strategic planning as recommended by Bandrowski with specific creative skills and their components are demonstrated in figure 8.

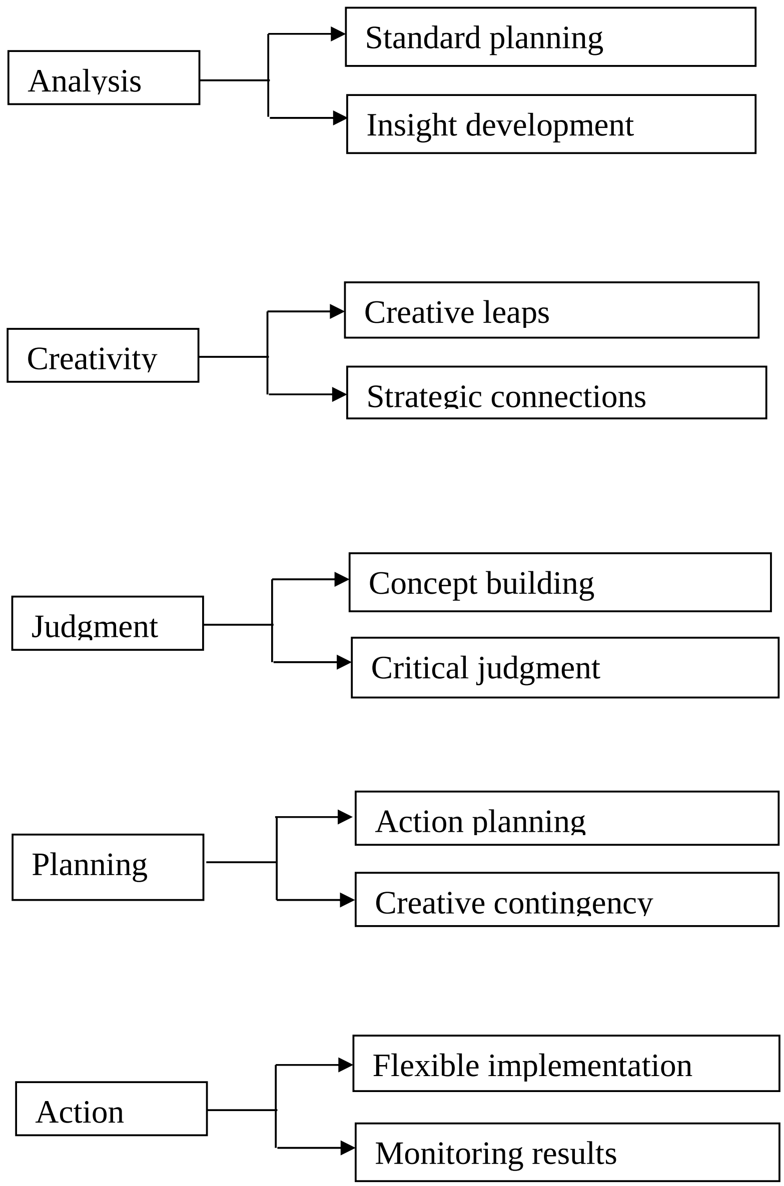


Figure 8. Model for creative strategic planning as recommended by Bandrowski

Barron's psychic creation model

Psychic creation model was proposed by Barron (1965) which stresses on sub consciousness. The structure of Barron's model supports the popular view of creativity as a mysterious process involving subconscious thoughts beyond the control of the creator. Some models emphasis on the conscious processes behind all thinking; however Barron's psychic creation model rejects this aspect. Phases described by this model are conception, gestation, parturation and bringing up the baby. The Barron's psychic creation model is given in table 8.

Table 8

Phases Described in Barrons Psychic Creation Model

No:	**Phases**	**Description**
Phase1	Conception	In a prepared mind
Phase2	Gestation	Time, intricately coordinated
Phase3	Parturation	Suffering to be born
Phase4	Bringing up the baby	Further period of development

Robert Fritz' process for creation

According to Fritz (1991) the process of creativity is cyclical in nature. According to him the process of creativity initiates in the creative acts of conception and vision. He stressed on the fact that 'Living with your creation' is purposefully noticing and analyzing, which leads to the next creative conception and vision. This is followed by analysis of current reality, action, evaluation, public scrutiny and completion. The Process of Creation recommended by Fritz is shown in figure 9.

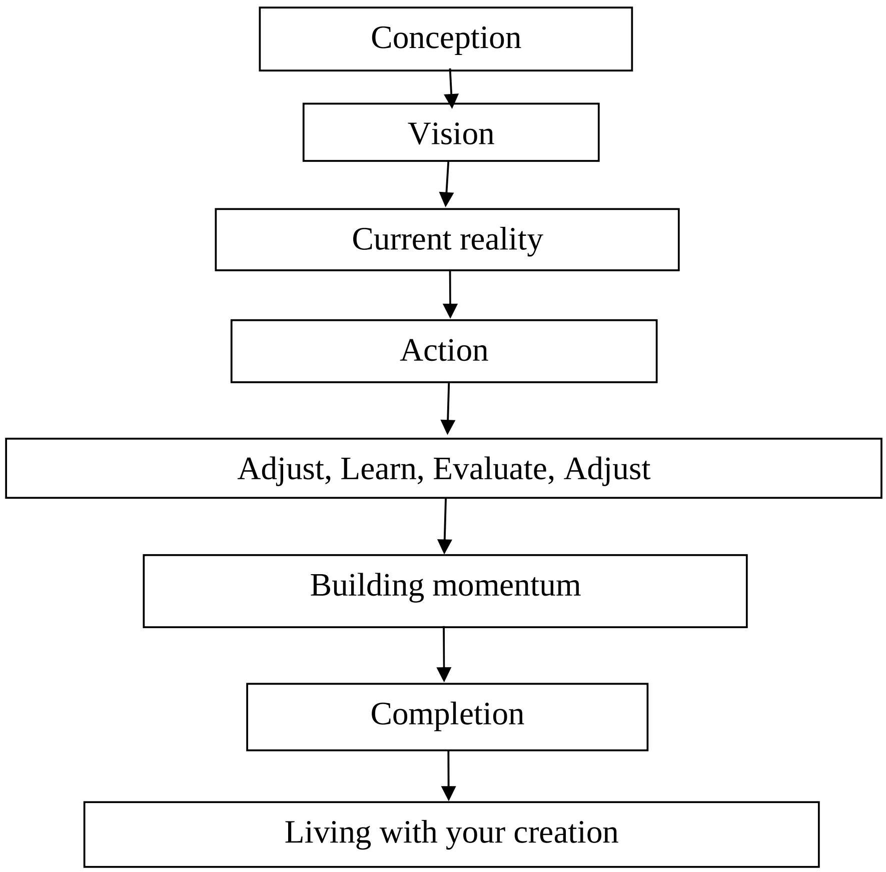


Figure 9. The Process of Creation recommended by Fritz

The creative problem solving model (CPS)

Parnes (1992) outlines six steps in his popular creative problem solving model. They are objective finding, fact finding, problem finding, ideas finding, solution finding and acceptance finding. In figure 10, details of steps involved in creative problem solving model is shown.

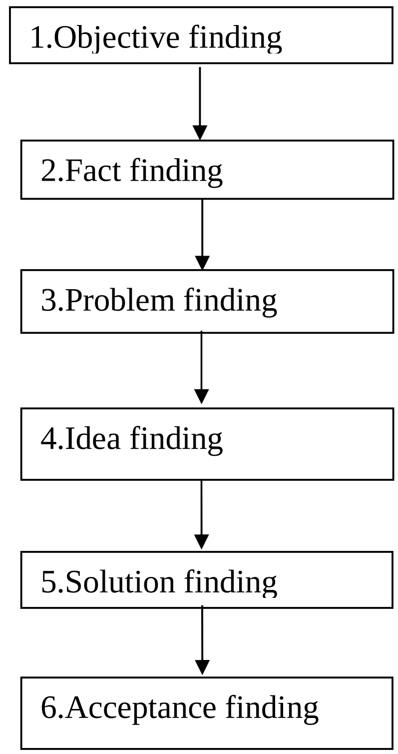


Figure 10. Steps involved in Creative Problem Solving Model

Scientific structure creativity model

Hu and Adey (2002) have a comprehensive view of scientific creativity as a process, person and a product. According to them scientific creativity is a kind of intellectual trait or ability producing a certain product that is original and has social or personal value, designed with a certain purpose in mind, using given information. They introduced a three dimensional model of creativity known as 'Scientific Structure Creativity Model' (SSCM). It has three dimensions namely scientific process, personality trait and scientific product. Scientific process involves two components viz., scientific thinking and scientific imagination. Personality trait of creativity involves fluency, flexibility and originality. The components of scientific product according to this model are technical product, scientific knowledge, scientific phenomenon and scientific problem.

Various models of creativity, their proponents and year are briefed as table 9.

Table 9

Details of Various Models of Creativity

Proponent	**Year**	**Models of Creativity**
Wallas	1926	Process of Creativity Model
Rossman	1931	Analytical Model of Creativity
Guilford	1950	Model of Structure Of Intellect (SOI)
Osborn	1953	Seven Step Model for Creative Thinking
Coberg and Bagnall	1981	Universal Traveler Model
Bandrowski	1985	Model for Creative Strategic Planning
Barrons	1988	Psychic Creation Model
Robert Fritz	1991	Process for Creation Model
Parnes	1992	The Creative Problem Solving Model (CPS)
Hu and Adey	2002	Scientific structure creativity model

Components of Creativity

The psychologist Sternberg (1988) has proposed the term ‘creatology’ as the scientific study of creativity. Creativity can be measured based on a response to a variety of test scenarios.

Torrance (1966) defined creativity as “a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies and so on, identifying the difficulty; searching for solutions, making guesses or formulating hypothesis and possibly modifying and retesting them; and finally communicating the results”. He identified four components through which individual creativity can be assessed. They are Fluency, Flexibility, Originality and Elaboration.

Fluency

Fluency means the ability to come up with many diverse ideas quickly. It is the number of relevant and acceptable responses.

Flexibility

Flexibility is the number of different categories or variety of responses. It indicates how many ways an individual respond to a particular stimulus. It is an indicative of the individual’s ability to respond to a similar situation, to think in a different mode and trying the unknown.

Originality

Originality is the ability to produce rare or uncommon responses, remote associations or connections among the participants of the study. It is measured as their infrequency of occurrence or novelty of ideas generated among the participants under study.

Elaboration

Elaboration means the amount of detail associated with an idea. It makes the production of detailed steps, variety of implications and consequences. It is the ability to elaborate upon ideas and fill them out with details.

The details of components of Creativity mentioned by Torrance are given in table 10.

Table 10

Components of Creativity Mentioned by Torrance

Sl. No.	**Components**	**Description**
1	Fluency	The ability to come up with many diverse ideas quickly. Number of relevant and acceptable responses.
2	Flexibility	The number of different categories variety of responses. Number of ways an individual responds to a particular stimulus.
3	Originality	The ability to produce rare or uncommon responses or remote associations Rarity of occurrence or novelty of ideas generated among the participants under study.
4	Elaboration	The amount of detail associated with an idea. The ability to develop ideas and fill them out with details.

Guilford (1967) gave first scientific explanation of creativity based on the model of structure of intellect. The components of creativity described by Guilford are

- Sensitivity to problems
- Fluency
- Flexibility
- Originality
- Redefinition
- Elaboration

Components and subcomponents of creativity as described by Guilford (1967) are given as table 11.

Table 11

Components of Creativity Mentioned by Guilford

No:	Component	Description	Sub components
1	Sensitivity to the problem	Awareness of defects, needs and deficiencies in the environment	Nil
2	Fluency	It is the ability to come up with many diverse ideas quickly.	a.Associational fluency b. Word fluency c. Ideational fluency d.Expressional fluency
3	Flexibility	It is the ability to cross boundaries and make remote associations	a.Spontaneous flexibility b.Adaptive flexibility
4	Originality	This measures how statistically deferent or novel the ideas are compared to a comparison group. The number of novel ideas generated, the uncommonness of ideas, the ability to see unusual consequences	Nil
5	Redefinition	It is the ability to improvise operation in situations where a familiar object may be used for unfamiliar functions	Nil
6	Elaboration	It is the ability for adding a variety of details to information that has already been produced	a.Pictorial elaboration b.Semantic elaboration

Details of six components of creativity mentioned by Guilford are described below.

Sensitivity to problems

Sensitivity to problems means awareness of defects, needs and deficiencies in the environment. A test of this ability is a set of questions asking for the defects which might be improved in common appliances in daily life.

Fluency

Fluency is the ability to come up with many diverse ideas quickly. According to Guilford (1967) fluency is the number of responses one can produce in a limited time. It is measured by the total number of ideas generated. The four fluency factors are given in figure 11.

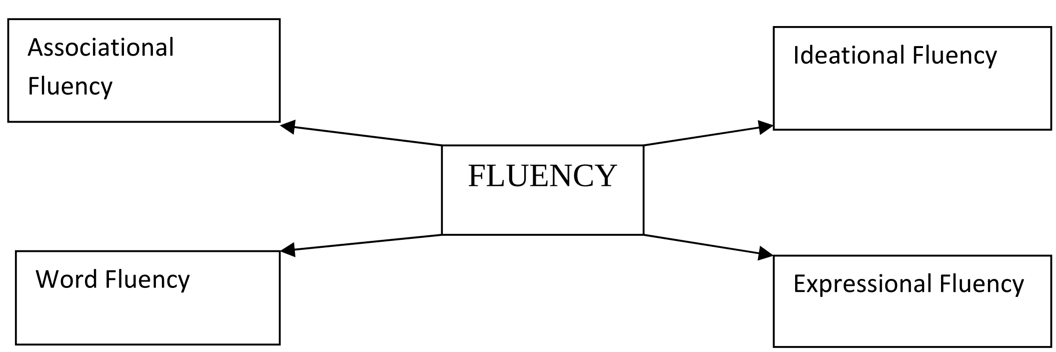


Figure 11. The four factors of Fluency described by Guilford

Flexibility

Flexibility is defined as a change of some kind – a change in the meaning, interpretation or use of something, a change in understanding of some tasks, a change in strategy in doing the task or a change in the direction of thinking, which may mean a new interpretation of the goal.

This captures the ability to cross boundaries and makes remote associations. This is measured by number of different categories of ideas generated. It is a matter of fluidity of information or a lack of fixedness or rigidity. Flexibility is the basis of originality, ingenuity and inventiveness. Two flexibility factors are spontaneous flexibility and adaptive flexibility.

Originality

This measures how statistically deferent or novel the ideas are compared to a comparison group. This is measured as number of novel ideas generated. It is a quality that can be demonstrated in several ways, one being the uncommonness of ideas a person has, another the ability to see unusual consequences of outlandish hypothesis such as, “ What would happen if people only had three fingers?”

Redefinition

Redefinition is the ability to improvise operation in situation where a familiar object may be used for unfamiliar functions, such as in the question, What are the various devices for pounding a nail into a wall as a picture-hanger?

Elaboration

Elaboration measures the amount of detail associated with the idea Elaboration has more to do with focusing on each solution/idea and developing it further. It is a facility for adding a variety of details to information that has already been produced. Creative productions often progress from a vague outline or theme, through development of a more clearly organized structure or system with essential aspects, then to the more elaborate finished affair, whether it be a poem, a novel, a painting or a scientific theory. These are implications to be followed up and finishing touches to be added in order to round out the final product. Elaboration can further be divided into pictorial elaboration and semantic elaboration.

Components of creativity, their proponents and year are briefed as table 12.

Table 12

Details of Components of Creativity

Proponent	**Year**	**Components of Creativity**
Torrance	1960	• Fluency • Flexibility • Originality • Elaboration • Sensitivity to problems
Guilford	1967	• Fluency • Flexibility • Originality • Redefinition • Elaboration

Index of Creativity

According to Getzels and Jackson (1962) the index of creativity or the most common criteria are achievement or accomplishment, ratings, intelligence, personality and creativity test score which are given as table 13.

Table 13

The Index of Creativity Described by Getzels

Sl.No.	Index of Creativity	Description
1	Achievement or Accomplishment	To identify achievements, which speak for themselves
2	Ratings	To provide a sound judgment of his inventiveness
3	Intelligence	Performance in an intelligence test which is an index of mental functioning
4	Personality	It is evaluated in relation to an empirically derived or on a prior profile of creative personality and the closeness of the fit are used as a criterion.
5	Creativity test score	Various instruments used for measuring creativity are Inkblot tests, observations and drawings. Poems, sketches, essays and stories written with the help of pictures are also used for measuring of creativity.

1. Achievement or Accomplishment

An attempt is made to identify achievements, which speak for themselves. For eg: Nobel Prize or some other mark of understanding accomplishment may be taken as an index that hardly anyone would dispute.

2. Ratings

It is assumed that a person who has an opportunity to observe another person can provide a sound judgment of his inventiveness. Evaluation by peers, supervisors and teachers has been used as a criterion.

3. Intelligence

Performance on intelligence tests is the most widely used and best validated index of mental functioning. Presumably creativity is a mental function and a superior IQ may be used as a criterion.

4. Personality

Characteristics of personality are evaluated in relation to an empirically derived or on a prior profile of creative personality and the closeness of the fit are used as a criterion.

5. Creativity Test Scores

Performance on creativity tests are the best index of creativity. Various instruments used for measuring creativity are Inkblot tests, observations and drawings. Poems, sketches, essays and stories written with the help of pictures are also used for measuring of creativity.

Measurement of creativity

Tools and techniques for measuring creativity were developed which helped identification of the extent of creativity among individuals and nurture it in its full potential through appropriate measures. The measurement of creative potential is very complex and it involves abilities for divergent production and the transformation categories.

Wallach and Kogan Creativity Test (WKCT)

Wallach and Kogan (1965) test is developed based on the associative conception of creativity. The items are graded from simple to complex. The child answers the questions like a play situation under verbal and non-verbal condition. The activity involves tasks (verbal) that generate possible instances of a class concept, alternative uses of an object, and similarities between objects, figural, pattern drawing and guessing of possible meaning from lines. The task performance is scored on number of associational responses generated under various contexts and uniqueness of these responses (Wallach & Kogan, 1965).

Torrance-Minnesota Test of Creativity

The Minnesota Test was developed by Torrance and his colleagues (Torrance, 1969). It is also known as Torrance Test of Creative Thinking (TTCT). It is developed based on Guilford's Structure of Intellect Model and it is a widely used test of creativity across the world. It is a tool to measure an individual's creative potentialities and involves both verbal and non-verbal aspects. TTCT is not designed to measure creativity rather it serves to foster Creative thinking. This test has both verbal and figural forms. A brief description of the tasks involved in verbal and figural tests are given below in table 14 and table 15 respectively.

Table 14

The Tasks Involved in Verbal Test of Creativity

Sl. No.	**Verbal task**	**Description of the task**
1	Asking questions	Ask questions about the given picture which cannot be answered by looking at the picture. It is to know what is happening in the drawing
2	Guessing causes	It is an ask and guess test. The participants are to make guesses about the possible causes. It requires analytical ability.
3	Guessing consequences	List the consequences of an improbable theme. It is resulting from the action and the drawing conclusions.
4	Product improvement.	Four objects (toys) are given. Give suggestion for its improvement. Commonly toys are used to make many improvements and to make it more different.
5	Unusual uses.	Objects are given. List the most unusual uses of it. Here the participants are required to redefine an object by giving cleverest, most interesting and most unusual uses. Eg. Give the unusual uses of tin, can or books.
6	Unusual questions	Unusual questions are required with regard to cardboard boxes.
7	Just suppose.	The subjects are confronted to list things that would happen in an improbable situation. That is to predict the possible outcomes.

Table 15

The Tasks Involved in Non-Verbal Test of Creativity

Sl. No.	Non-verbal task	Description of the task
1	Figure or picture completion test	Six incomplete figures are given. Add lines, complete figure using stimulus figure and give titles. Creative design task – Construct designs using the given circles, strips of colors, booklet, scissors and glue.
2	Picture or figural construction test	Construct a picture that includes the given shape. The participant has to think of a picture and its shape. It should be a unique one.
3	Parallel lines test	Make pictures from pairs of straight lines

All the above tests are assessing the subject's divergent thinking abilities based on components of creativity such as fluency, flexibility, originality, elaboration etc.

Theoretical Overview of Mathematical Creativity

Definitions of Mathematical Creativity

Most of the existing definitions of Mathematical Creativity are vague and there is no generally universally accepted definition for it. However definitions of some mathematicians like Poincare, Laycock, Ervynck and Sriraman are worth notable and mentioned below.

Getzels (1961) classified definitions of creativity into three categories viz., manifest product, underlying process and subjective experience.

The definitions of Mathematical Creativity under product category are given below.

According to Calton (1959) creative thinking in Mathematics is a special kind of thinking which results in additions to knowledge where as Spraker (1960) defines Mathematical Creativity as the ability to produce original, unusual and applicable methods of solution for problems in Mathematics.

The definitions of Mathematical Creativity under process category includes that given by Romey (1970), Laycock (1970) and Sriraman (2004).

According to Romey (1970) Mathematical Creativity is the ability to combine mathematical ideas things, techniques and approaches in a new way whereas Laycock (1970) defines Mathematical Creativity as the ability to analyze a given problem in many ways, observe patterns, see likeness and differences and on the basis of what has worked in similar situations decide on a method to solve the problem in an unfamiliar situation.

Sriraman (2004) defines mathematical creativity as the process resulting in unusual and insightful solutions to a given problem, irrespective of the level of complexity and the publication of original results in a prominent mathematical research journal. He defined Mathematical Creativity in terms of originality and usefulness. He distinguished Mathematical Creativity between school level and professional level which provides new insights in mathematical situations and idea of new association at school level. According to him it is not practical for the identification and development of Mathematical Creativity in school students. However in the higher levels (professional levels) Mathematical Creativity can be defined as

1. The ability to produce original work that significantly extends the body of knowledge
2. The ability to open up venues of new question for other mathematicians.
3. The process that results in novel unusual, insightful solution to a given problem or analogous problems.
4. The termination of new question or possibilities that allow an old problem to be regarded from a new angle.

The definitions of Mathematical Creativity under subjective experience (person) category are the following.

Hadamard (1954) defined Mathematical Creativity as the ability to see new relationships between techniques and areas of application and to make associations between possibly unrelated ideas.

Poincare (1956) defined Mathematical Creativity as an ability to choose from a large number of possible combinations of mathematical proposition.

According to him there is a lot of combination of mathematical ideas, but a few of them are useful and a minimal collection leads to the proof. In the process of identifying useful mathematical combinations, a large number of combinations are made and then isolating meaningful and useful ones from it. In his words Mathematical Creativity is the process of forming, recognizing and choosing useful meaningful and important from them.

According to Ervynck (1991) Mathematical Creativity is the ability to generate mathematical objects. It involves the generation of an idea to cop up with a mathematical problem with in a mathematical situation. According to him the characteristics of Mathematical Creativity are relational selective and compressed or briefly presentable. In his opinion, if an individual creates a useful mathematical concept by combining known concepts or discovering unknown relations between mathematical concepts. This act of finding new mathematical ideas or combinations is considered as an act of doing creative Mathematics.

The details of various definitions of Mathematical Creativity put forward by various thinkers are listed in table 16.

Table 16

Details of Various Definitions of Mathematical Creativity

Proponent	Year	Definition of Mathematical Creativity
Hadamard	1954	Ability to see new relationships between techniques and areas of application and to make associations between possibly unrelated ideas.
Poincare	1956	Ability to choose from a large number of possible mathematical combinations. Process of forming, recognizing and choosing useful meaningful and important from them.
Calton	1959	Creativity thinking in mathematics is thinking which results in additions to knowledge.
Spraker	1960	Ability to produce original, unusual and applicable methods of solution for problems in mathematics.
Romey	1970	Ability to combine mathematical ideas things, techniques and approaches in a new way.
Laycock	1970	Ability to analyze a given problem from various dimensions. Seeing various patterns, their differences and similarities, generate a number of ideas and at last choosing a proper method to deal with unfamiliar mathematical situations.
Ervynck	1991	Ability to generate an idea to cop up with a Mathematical problem within a mathematical situation Ability to create a useful mathematical concept by combining known concepts or discovering unknown relations between mathematical concepts
Sriraman	2004	Ability to produce original work that significantly extends the body of knowledge. Ability to open up venues of new question for other mathematicians. Process resulting in novel unusual, insightful solution to a given problem and viewing an old problem from a new angle.

Approaches on Mathematical Creativity

Pragmatic Approach

Rather than understanding the concept and various aspects of Mathematical Creativity pragmatists believed the practical side, that is, its development. Polya (1954) analyzed the usage of various heuristic methods for solving Mathematical problems. Brain storming is a typical example for inducing creativity by seeking many solutions as possible for a problem.

Psychodynamic Approach

According to Hadamard (1945) and Poincare (1948) Mathematical Creativity arises from the disequilibrium between conscious reality and unconscious drives as that of general creativity. The four step Gestalt model with steps preparation, incubation, illumination and verification is identified as the characteristic of Mathematical problem solving as mentioned by Schoenfeld (1985) and Lester (1985).

Cognitive Approach

The basic idea of cognitive approach to Mathematical Creativity understands the mental representations and processes involved in thinking. According to Weisberg (1993), creativity makes use of ordinary cognitive process resulting in extra ordinary results. In Mathematical Creativity the input is Mathematical concepts and the final product is the original, unique solutions to problems.

Mystical Approach

Many of early Mathematicians believed that their creative abilities are due to the divine inspiration. Early Mathematicians like Pascal and Kronecker asserted in their book that their Mathematical insights are gifts directly from God (Gallian, 1994). The research works conducted by Hadamard (1945) and Poincare (1948) about the nature of Mathematical Creativity indicate that the innate belief and intuitions of Mathematicians help creative contributions.

Psychometric Approach

The tests of Mathematical Creativity allows for researches in the positive side of the psychometric approach whereas numerical scores fail to capture the concept of Mathematical Creativity is its negative side, since it is based on pencil and paper tests . Torrance test of creative thinking consisting of several verbal and figural tasks (Torrance, 1960) is an example for this category. Writing samples, drawings etc. subjectively evaluated by a panel of experts are more significant measures than numerical measures.

Social –Personality approach

Sternberg (2000) proposes social – personality approach to the study of creativity. According to him 'eminent levels of creativity over large spans of time are statistically linked to variables such as cultural diversity, war, availability of role models, availability of financial support and competitors in a domain. The sources of creativity are personality and motivational variables and socio – cultural environment.

Various approaches on Mathematical Creativity put forwarded, its proponents and year are listed below in table 17.

Table 17

Details of Various Approaches of Mathematical Creativity

Proponents	**Year**	**Approaches of Creativity**
Polya	1954	Pragmatic Approach
Hadamard	1945	
Poincare	1948	Psychodynamic Approach
Schoenfeld	1985	
Lester	1985	
Weisberg	1993	Cognitive Approach
Gallian	1994	Mystical Approach
Torrance	1960	Psychometric Approach
Sternberg	2000	Social Personality

Models of Mathematical Creativity

Hadamard's Four Stage Model of Mathematical Creativity

According to Hadamard (1945) rather than conscious and logical, creative mathematical thinking is unconscious and intuitive. There are stages involved in the process of mathematical creativity viz., preparation, incubation, illumination and verification. Preparation, the first stage of mathematical creativity is a stage of preparing with concentration and deep involvement in the problem. During the second stage of incubation, the problem is set aside for some period of time and continues other works. This stage is characterized by the unconscious level in the process of mathematical creativity. When the unconscious level is successful, the third stage of illumination or insight into the solution occurs all of a sudden. At the last stage of verification, verification of the results, refinement of the obtained solution and elaboration occurs.

Polya's five stage Model of Mathematical Creativity

Polya (1954) introduced a five stage model of mathematical creativity related to problem solving. According to him problem solving in Mathematics is a complex process which demands analysis of different aspects of a problem from various dimensions. In the process of solving of a mathematical problem, mathematicians use a variety of heuristics. The stages involved in mathematical creativity related to problem solving according to Polya are

1. Verifying consequences
2. Successively verifying several consequences
3. Verifying an improbable consequence
4. Inferring from analogy
5. Deepening the analogy

Ervynck's three stage Model of Mathematical Creativity

Ervynck (1991) proposes a three stage model of Mathematical Creativity. There are preliminary technical stage, algorithmic activity and creative activity. In the preliminary technical stage, some types of technical and practical application of Mathematical rules and procedures are involved. In this stage, the individual is acting without any theoretical foundation and hence it was also named as stage-zero.

In the Algorithmic activity stage the individual performs primary Mathematical techniques. This stage is characterized by the repeated application of algorithms explicitly. The third or the final stage of Mathematical Creativity is known as stage of Creative Activity. It is characterized by conceptual and constructive activity. This stage consists of non-algorithmic decision making and occurs the true Mathematical Creativity.

According to him, creativity in Mathematics plays an important role in the sphere of advanced Mathematical thinking. The stages proposed by Ervynck are briefed in table 18.

Table 18

Various Stages of Mathematical Creativity Proposed by Ervynck

No.	**Stages**	
1	Stage 0	Preliminary technical stage
2	Stage 1	Algorithmic activity
3	Stage 2	Creative activity

Various models of mathematical creativity, their proponents and year are briefed as table 19.

Table 19

Details of Various Models of Mathematical Creativity

Proponent	**Year**	**Models of Creativity**
Hadamard	1945	Four stage Model of Mathematical Creativity
Polya	1954	Five stage Model of Mathematical Creativity
Ervynck	1991	Three stage Model of Mathematical Creativity

Theories on Mathematical Creativity

Investment Theory

Creative individuals are like good investors as mentioned by Stenberg and Lubart (1995). The creative people invest a good time for convincing others about the intrinsic worth of their creative ideas. The high sale value of creativity in the sense they let others pursue their idea. In other words, we can say creative people are the trend setters in the society. Six elements constituting creativity according to this theory are intelligence, knowledge, thinking styles, personality, motivation and environment. According to the theorists the personality traits support to nourish creativity are willingness to take risk, overcome obstacles tolerate ambiguity, motivation, supporting environment and reward (Sternberg, 1988). According to investment theory of Mathematical Creativity, Mathematical Creativity is not just a simple sum of six elements of it; but it required certain threshold of knowledge. Creative endeavors can be encouraged with a high level of motivation, if an individual is in a non-supportive environment.

System Theory of Mathematical Creativity

Mathematical Creativity involves the interaction between a person, task and environment, according to Csikszentmihalyi (2000). Novelty or originality of creativity varies person to person, task to task and environment to environment. This theory considers cultural and social dimensions of Mathematical Creativity rather than individualistic process. The field consists of individuals having any type of interaction or influence on the domain. An observable interaction between the three components of a system viz., individual, domain and field are necessary aspects of this theory on Mathematical creativity.

Various theories on Mathematical Creativity, its proponents and year are listed in table 20.

Table 20

Details of Various Theories of Mathematical Creativity

Proponents	**Year**	**Approaches of Creativity**
Stenberg and Lubart	1995	Investment Theory
Csikszent Mihalyi	2000	System Theory

Measurement of Mathematical Creativity

Fleith (2014) have summarized various measurements of Mathematical Creativity in which attempts of Spraker, Prouse, Buckeye, Meyer's, Foster and Mainville are explained

Spraker (1960) constructed a test of Mathematical Creativity for seventh graders with thirty one mathematical problems. In this test, the respondent has to solve each problem in as many different ways as he can. The score for each response is according to its infrequency, that is the most common response gets smallest score (from 1 to 4). The test score is the sum of scores in all the problems the examinee attempts.

Prouse (1967) designed a creativity test in Mathematics having ten items for the seventh standard students. It is intended to measure creativity potential in the subject of mathematics. In this test seven items measure divergent thinking ability and three items measure convergent thinking ability.

Buckeye (1970) designed a test of creative ability in mathematics for college students. This test consists of six items on divergent thinking which are scored for fluency only.

Meyer's (1970) measures of Mathematical Creativity in first graders employ behavioral ratings in six criteria. Among them five criteria describe activities engaged in by a creative person attempting to solve a problem and the sixth criteria describes the result of these actions.

Foster (1970) constructed two tests (A & B) to measure the creative abilities in Mathematics of primary school children of 9 to 11 years of age. In test I the student has to select six cards from a deck. These cards have some common attributes and the number of sets constructed within 5 minutes is counted. In test II, the student is asked to find as many sums as possible using the numbers 2,3 and 6 with four fundamental operations.

Mainville (1972) designed a test on Mathematical creativity for college students. This test consists of two forms A and B, each composed of 5 divergent thinking items. Mainville's test items are scored for both fluency and originality.

Review of Related studies on Creativity

Moltafet, Firoozabadi and Raisi (2018) conducted a correlational study between parental styles and emotional creativity. The mediating role of fulfillment of basic psychological needs was also examined in the study. The sample selected for the study included three hundred and seventy five under graduate students. The sampling technique used in the study was multi-stage cluster sampling. Emotional creativity inventory, Parents as social context questionnaire and Basic psychological needs scale were the tools used to collect data. The results of the study revealed that parenting style and basic psychological needs influence the emotional creativity of the learners. The study reflects on the mediating role of parenting style on emotional creativity.

Daunis and Scullin (2017) conducted an experimental study among undergraduate students in order to find the relationship between duration of sleep and measures of creativity. Forty-one undergraduate students participated in an experiment of two sessions. The session one involved a virtual course of microeconomics along with laboratory based measures of creativity. During the first session participants kept a sleep diary and wore wristband actigraphy to measure their sleep. The second session involved creativity tests and micro economics tests. Participants slept for 7 to 9 hours per day are termed as normal sleepers who scored higher in creativity tests and microeconomics tests than short and long sleepers.

Yeh and Lin (2017) conducted a study among elementary school students to identify and explore how player related factors influence the learning outcomes of digital creativity games. Two hundred and seventy five students from fourth to sixth grades participated in the experimental study. Five inventories developed by the investigator were employed in the study. The findings of the study revealed that the participants spend a large proportion of time playing digital games after school. The results suggest that motivation for achieving both mastery goals and performance goal is crucial for enhancing self- efficacy and achieving mastery experience in creativity. The study shed light on the design of digital games for creativity training.

Kim, Park, Yoo and Kim (2016) conducted a study for examining the effects of an instructional model that leverages innovative technologies in the classroom to cultivate collaboration that improves student's comprehension, fosters their creativity, and enables them to better express and communicate their ideas through drawing. This study focuses on classroom interaction systems and technologies that can foster creativity, including tablets, electronic blackboards, interaction management solutions, and high-speed wireless internet. The participants of the study were two hundred and sixty two seventh grade students from a government school in Korea. The study aims at conceptualized an instructional model entitled "Visual Thinking through Tablet-based Classroom Interaction" (VTTCI). It was applied for one semester in English classes in a high-tech middle school in Korea. After applying the instructional model for one semester, the creativity of the students was assessed using the Torrance Tests of Creative Thinking-Figural form, (TTCT). The results revealed that the students in the treatment group scored significantly higher on originality, abstractness of titles, elaboration sub scales and overall creativity. The results showed that the student's creative proficiency improved with the adoption of the instrumental model for tablet- based interactive classrooms.

Liu, Lu, Wu and Tsai (2016) conducted a study among sixth grade students to investigate the impact of peer review on creative self efficiency and Learning Performance in Web 2.0 Learning Activities. This study proposes an approach to leveraging Web 2.0 learning activities and classroom teaching to help students develop both specific knowledge and creativity based on

Csikzentmihalyi's system model of creativity. The approach considers peer review as the core component in the learning activities with the aim of engaging students in the creative learning paradigm. The participants of the study were 53 sixth graders from an elementary school in northern Taiwan. The participants did not receive specific study in story telling skills. The experiment lasted for eight consecutive weeks and involved one hour per week of class time. In order to facilitate the peer review of students' creative performance, a set of creation rubrics associated with storytelling was administered. The results showed that students who experienced the peer review using a set of storytelling rubrics produced significantly more sophisticated stories than those who did not. It was also found that the experimental group's creative self-efficacy consistently reflected their performance; while the control group's creative self-efficacy did not.

Varghese (2016) conducted a study on the development of educational courseware for enhancing appreciation and creativity in English poetry among secondary school students. Two hundred and eighty seven ninth standard students participated in the study. An educational courseware on English poetry was developed as well as lesson plans were prepared. Both the tools were implemented to experimental group whereas no special treatment to the control group. In the study experimental method with pre-test post-test non-equivalent group design was adopted and stratified random. Sampling method was used. Results of the study revealed that appreciation and creativity in English poetry has significantly enhanced by Educational courseware among secondary school students. In this study three components of creativity namely fluency, flexibility and originality was measured and all of them have significantly improved among the sample by the use of Educational courseware.

Yeh and Lin (2015) conducted a study aimed at understanding whether the aptitudes of meaning-making, self-regulation, and knowledge management (KM) would interact with the treatment of 17-week KM-based training and then influence creativity in e-learning. The participants were 31 university students, and all variables were measured using online systems. The instruments employed in the study included an e- learning website and an online experimental system developed in php and java script. The findings of the study revealed that the creativity measured by divergent thinking test or digital imagery test was closely related to the participants' product oriented creativity. The close relationships between interventions, knowledge creation and creativity performances suggest that the interventions are effective and improving the participants creativity.

An experimental study was conducted by Smogorzewske (2014) in order to develop language creativity through telling stories among children. The participants of the study were 460 five-year old, polish speaking children who attended kindergarten. There were two experimental groups; one using the Storyline method and the other Association Pyramid method. But the control group used only the method of Reading. The study was conducted in four stages of individual examination. The findings of the study indicates that the method used in the experimental method is effective than control group. This study confirmed the effectiveness of 'Storyline' and "Association pyramid" methods for developing language creativity among kindergarten children.

Topno (2014) investigated on the relationship between Emotional Intelligence, Creativity and teacher effectiveness of primary school teachers. The study incorporates creativity as well as emotional intelligence with teacher effectiveness and teaching competency. The objectives of the study were to find the level of Emotional Intelligence, Creativity and Teacher Effectiveness in Primary School Teachers. Also it aims to find the relationship and influence of Emotional Intelligence and Creativity in Teacher Effectiveness. It was found that Emotional intelligence and creativity are inseparable dimensions to measure the effectiveness of teachers practicing at schools.

Anjali (2013) conducted an experimental study among the play school children with regard to the behavioral profile, creativity, problem solving ability and social cognition. The study was conducted on a sample of 300 preschool students among them 150 had attended play school and remaining 150 had not attended play school. The result of the study indicates that there is a positive influence for the play school on the behavioral profile, creativity, problem solving ability and social cognition of the preschoolers.

A study on qualifications, teaching experience and creativity score was conducted by Jayaram (2013). The participants were secondary school students. The result of the study indicates that professional qualifications and teaching experience of teachers do not make any differences in creativity scores of the students.

Kuveri (2013) conducted an experimental study among secondary school students about the effectiveness of concept mapping on scientific creativity. The selected sample was ninth standard students from two schools of Malappuram district. Findings of the study revealed that concept mapping is highly effective in developing scientific creativity.

Singh (2013) made an attempt to predict academic achievement on the basis of achievement motivation, emotional intelligence and creativity. The sample comprised of seven hundred and forty five student teachers from Amritsar. Creativity test developed by Mehdi was used for measuring creativity. The study reveals that Creativity has no direct influence on academic achievement.

Gupta (2012) investigated the effect of socio-demographic factors such as environment, gender and parental education on creativity and intelligence of senior secondary students. Normative survey method was used and the sample was one hundred and twelve senior secondary students. Jalota’s group test of general mental ability and Mehdi’s verbal test of creative thinking were used for measuring intelligence and creativity respectively. There observed no significant difference in intelligence as well as creativity with respect to gender. But creativity varied significantly due to parental education. Also a significant difference was found between urban and rural students in terms of creativity.

The originality component of scientific creativity talent was investigated by Rawat and Kumar (2012). Verbal test of scientific creativity was used for collecting data. The participants of the study were one thousand and twenty elementary students of Himachal Pradesh. It was found that the elementary students of Government schools have higher flexibility scores. Also there is a significant difference in the originality of elementary students of rural and urban areas.

Albert (2011) made a longitudinal research on the use of task based language teaching. This research project was intended to help students use their imagination to generate new ideas. The sample of the study comprised of 67 students including five Hungarians. A standardized creativity test developed by the investigators was used to test creativity of the participants. Findings of the study revealed that all the components of creativity are highly effective on narrative task performance.

Baran, Erdogan, and Cakmak (2011) conducted a study on the relationship between Creativity and Mathematical ability of six year old students. In this study, data for creative ability were collected using Torrance Tests of Creative Thinking. Data for mathematical ability were gathered using a mathematical test, measuring aspects of informal and formal Mathematics. It was found that there is no significant relationship between mathematical ability and creativity. Also there was no significant relationship between mathematical ability and creativity components such as fluency, originally and elaboration.

A comparative study was conducted by Hong, Hartzell and Greene (2009) in teachers Epistemological Beliefs, Motivational and Goal orientation to their instructional practices that foster student creativity. Teachers with sophisticated beliefs about knowledge and high intrinsic motivation for creative work found to be supporting student creativity through specific instructional practices. It was found that creativity fostering instructional practices were not significantly affected by teacher's motivation for challenging work, beliefs about learning and performance goals.

Upadhyaya (2011) conducted a study to find out the relationship between creativity and socio economic status. The participants of the study were two hundred high school students. The result indicates that there is no significant difference in the creativity level of students at different levels of socio economic status.

Yadav and Wadhwa (2011) examined impact of creativity on academic achievement. The participants were adolescents studying in English medium and Hindi medium schools. The results indicate that there is no impact of creativity on academic achievement. The girls and boys of English medium school possess more creativity and they are good achievers than the girls and boys of Hindi medium schools.

Syh-jong (2010) conducted a study on how web-based technology could be utilized and integrated with real life scientific materials to stimulate the creativity. Participants of the study were certified science teachers and thirty one seventh graders. The result of the study indicates that the student's creativity was motivated by the online inter-activities and the teacher's inquiry. Also there is a need to change student's expression of sensitivity, fluency, flexibility, originality and elaboration of scientific creativities.

Alam (2009) investigated the relationship between academic achievement with creativity as well as achievement motivation. The study aims to find out the extent of relationship between creativity and achievement motivation of the students and academic achievement. It was found that there exists a significant positive correlation between creativity and academic achievement as well as between achievement motivation and academic achievement. Analysis leads to the conclusion that both creativity and achievement motivation have a significant role on the academic achievement of students.

The effect of Scientific Process Skills Education on student's Scientific Creativity, Science Attitudes and Achievements in science was examined by Hilal and Omar (2008). The participants of the study were forty seventh grade students of an elementary school in Turkey. A combination of Force and Motion Chapter Achievement test, the science Attitude scale, and the scientific creativity scale were used for collecting data. It was explored that the Scientific

Process Skill Education increased the student's achievement and scientific creativity. No meaningful progress was made on their attitude towards science when compared to the teacher-centered method.

Kim (2008) conducted an analysis of the available literature on creativity and reported that the underachievement of gifted students may be tied to the interest and unrecognized creativity. He is of the opinion that many gifted students were under achievers and up to 30 percent of high school dropouts would be highly gifted.

Meera and Menon (2008) conducted an experimental study to find out the effectiveness of Synectics model of teaching on creativity. In this study one group pre-test experimental design was used and thirty nine higher secondary students were participated. The results indicate that high intelligent group differed in their creative performance from low intelligent group. It was also found that teaching through Synectics model can influence the creativity of students.

Reddy (2008) investigated the influence of gender on creativity of student teachers studying in teacher education colleges. The result of the study indicates that male and female student teachers do not differ significantly with respect to their creativity.

Vasugi and Kalavathy (2008) measured the scientific creativity among two hundred high school students of Dindingal District. To collect data a

Verbal test of scientific creativity was administered. It was found that the scientific creativity of high school students differs significantly with respect to living place, medium of instruction, type of school, educational qualification of parents and income. Also there is a significant positive correlation between scientific creativity and achievement in science.

Ward (2008) conducted a comparative study to find out the relationship between domain instances and both the originality and practicability of outcomes in a task in which participant designed novel sports. The result of the study indicates that there were links between tested knowledge and the rated practicability of the design.

Charyton (2007) investigated similarities and differences in general, artistic and scientific creativity between engineering versus music students. One hundred music and one hundred and five engineering students participated in the study. Results of the study indicate that musicians scored high in general and artistic creativity where no significant difference in scientific creativity was observed between the two groups.

Ismail (2007) conducted an experimental study among higher secondary students to find the effect of certain strategies of teaching English on nurturing creativity. The participants of the study were 160 higher secondary students. A strategy of developing speaking skills and another strategy for developing vocabulary were used for experimentation. Findings of the study indicates that the strategies for teaching English used by the investigator have significant effect on nurturing creativity among the higher secondary school students.

Jacob (2007) studied the relationship between creativity and self-concept. Findings of the study reveal that there is a positive correlation between creativity and self-concept. Here the researcher emphasized the significance of creativity as well as the need for developing good and positive self-concept for fostering creativity.

Aurora and Fuentes (2006) made an attempt to evaluate the relationship between creativity, temperament, character and psychopathological distress. It was a comparative cross- sectional study with three groups, viz., highly creative people with outstanding artistic of significant achievement, people without mental disorder and psychiatric outpatients. A test on creativity was administered. Highly creative individuals achieved low score on psychopathology. It was also found that there is a strong negative correlation between creativity and psychopathology on all sub-scales. Psychopathology was more related to personality than to creativity.

The impact of Environment in predicting creativity of children was investigated by Kaur (2006). The result of the study indicated a significant positive correlation between creativity and home environment. Also children of urban school scored higher on all four aspects of creativity than their rural children. It was found that urban schools were better than rural schools in terms of physical facilities, school activities and teacher’s behavior.

Sak and Maker (2006) studied the developmental variations in children's creative Mathematical thinking as a function on schooling, age and knowledge. A mathematical test was administered to measure mathematical knowledge and divergent production abilities such as originality, flexibility, elaboration and fluency. It was found that knowledge has a significant contribution in explaining variance in divergent production abilities such as originality, flexibility and elaboration in fourth and fifth graders.

The effectiveness of Industrial Engineering and Management (IE&M) Curriculum Reform Programme in foresting student's creativity was investigated by Chi-Kunag, Bernad and Kuang-yiao (2005). The study was conducted on one hundred and seventy seven IE and undergraduates from Yuan-Ze University. To measure changes in their creativity Torrance Tests of Creative Thinking (TTCT) was used. The findings of the study indicate that the students, after completing this reformed curriculum program had significantly improved their creativity.

Claxton, Pennels and Rhoads (2005) explored the developmental trends in creativity of school-age children. Data were collected from twenty five students each from fourth, sixth and ninth grades. The study explored the developmental trends in creativity from the fourth grade through beginning adolescent in the nineth grade. Both cognitive and affective processes related to creative production were assessed using a measure of divergent thinking.

Kurtzberg (2005) in an empirical study explored objectively measured creative fluency and subjectively perceived creativity in cognitively diverse teams. Results of the study indicate that cognitive diversity is beneficial for objective finding. It is affecting the member's creative performance. It is also indicates that creativity is a complex multi-dimensional construct and cognitive diversity is an important predictor of team emotions and outcomes.

Prieto and Sanchez (2005) studied the relationship between creativity and intelligence. In the study the threshold theory was analyzed for visual-special, naturalist and linguistic intelligence from a multidimensional perspective. The result of the study indicated a low correlation between them.

Rao (2005) conducted a comparative study in two hundred secondary school students. The scientific creativity of Navodaya students and Private students were compared using a standardized test namely Verbal Test of Scientific Creativity (VTSC). It was inferred that students of Navodaya schools are better in their Scientific Creativity level than that of private students.

Hong and Aqui (2004) examined the cognitive and motivational characteristics of adolescents gifted in Mathematics. The results revealed that creative students in Mathematics were cognitively more resourceful than their peers who achieved high grades in school mathematics. They used more cognitive strategies than the academically gifted. It was also found that creatively talented males showed more effort than academically gifted male students.

Jyothilekshmi (2004) conducted a study in secondary school students to find out the influence of gender and type of school management on creativity. It was found that there is no significant difference in government and private aided secondary school students for the whole samples with respect to total creativity. The study also reveals that there is no significant difference between the government and private aided girl students with respect to originality but the total creativity of the boys in private aided schools was greater than that of boys in government schools.

Slavica (2004) conducted a survey on the relations between creativity, academic performance and academic preference. Results of the study reveal a low positive correlation between creativity and achievement in the sub sample of girls. It was concluded that initial step in the acquisition of knowledge will contribute to creative thinking of students.

Sreekanth (2004) conducted an analytical study about the societal role in development of creativity among children. He is of the opinion that the influence of society in the form of parents, teachers and school administrators should consider the learner-centric, learner-friendly aspects while developing curriculum.

Banerjee and Debasri (2003) conducted a comparative study on self-concept and cognitive style of creative and non-creative students. The samples selected in the study were five hundred and sixty school students from seventh and eighth standards. Grade-wise comparison showed students of seventh standard are relatively higher than eighth standard in cognitive style and self-concept. Hence it concluded that cognitive style and self-control are independent of grade. It was also found that there exists a significant positive correlation in cognitive style and self concept with creativity. Major findings were that the factors discriminating between high, moderate and low creative are fluency, both verbal and non-verbal elaboration and originality. Cognitive style did not significantly discriminate between creativity groups.

Hu and Adey (2002) developed a test on scientific creativity among secondary school students. A scientific creativity structure model (SCSM) was also constructed as part of the study. The sample selected for the study includes 160 secondary school students in England. A scientific creativity scale of seven items was used to collect data. The findings of the study reveal that scientific creativity of the secondary school students' increase with increase in age and science ability is a necessary but not sufficient condition for scientific creativity.

Baker and Rudd (2001) examined the relationship between critical and creative thinking. It was concluded that collegiate educational experience has little effect upon the students' ability to be creative and on their dispositions to think critically. In fact the college experience should include an opportunity to discover one's potential and achieve high levels of creative expressions. The results of the study indicated that the two constructs -Critical and Creative thinking- are not closely connected.

Mahapathra (2000) explored the effectiveness of enrichment programmes in developing creative expressions at elementary stages. The result of the study indicates that girls were found to be better in developing composition writing when compared to boys. It was also found that the experimental treatment using enrichment programmes had a positive impact on the overall performance of the children.

Adey (1999) investigated the influence of Cognitive Acceleration through Science Education (CASE) program on the Scientific Creativity. The participants were secondary schools students and Scientific Creativity is measured by Scientific Creativity Test. It was found that the program promoted the overall development of Scientific Creativity. However the effects on different aspects of Scientific Creativity varied significantly.

Ajithakumari (1999) conducted a correlational study for finding the correlates of Creativity and nurturing the creative potential. The study was conducted in pre-school children between 3 to 5 years. In the study it was found that intellectual characteristics, language characteristics, social characteristics and home environment have significant effect on creativity and its nurturing.

Bhogayata (1998) conducted a study on the relationship among creativity, self-concept and locus of control. Results of the study indicate that the students with higher self-concept were more fluent, original and creative than the students with a lower concept.

Dahiya (1995) investigated the effect of mastery learning strategy on the creative abilities and achievement in Mathematics. A sample of seventy students of secondary schools from Delhi took part in the study. The results of the study showed that the group of students taught through mastery learning strategy had scored significantly higher on the criterion achievement test than the group of pupil taught mathematics through conventional method.

Prasad (1993) conducted a study in order to find out the effect of gender difference on creativity. Forty boys and forty girls of sixth standard in two Navodaya Vidyalaya of Orissa participated in the study. To collect the data Torrance Test of Creative Thinking was used. It was observed that the girls differ significantly in the measures of originality from the boys. In all the other creativity components gender difference is not significant.

Jain (1992) conducted a study on creativity in relation to the teaching aptitude, skills and personality variables of teachers. The results of the study indicate that there is a positive and highly significant correlation between creativity and classroom creativity, teaching aptitude and teaching skills.

Sreekala (1991) investigated the effect of attitude variables and intelligence on creativity. The findings of the study indicate that the attitude variables and intelligence are significantly related to creativity. The study reveals a positive correlation between creativity and intelligence among the participants.

Ashalatha (1990) investigated the relationship between problem solving ability and creativity. A specific creativity test was developed and administered among children. The students were grouped into high, average and low according to their creativity score. The study indicates that high, average and low groups of creative pupil differ in their problem solving ability.

Naja (1989) conducted a study on the relationship between the factors of creativity and achievement in Mathematics. The participants were nine hundred and sixty ninth standard students selected using stratified random sampling technique. The results showed that increase in creative thinking was attended by a corresponding increase in the achievement in Mathematics and creativity has a determining influence on achievement in Mathematics.

Jayasree (1988) examined the effect of select attitude variables on creativity of secondary school students. The results of the study indicate that the effect of attitude towards problem solving, attitude towards mathematics and attitude towards education on creativity are significant.

Hermmelin and O'connor (1986) conducted a study on comparison of Mathematically and artistically gifted children and two IQ matched subgroups for their ability to carry out several types of visual-spatial tasks. It was found that mathematically gifted children were better than all the other groups in solving problems and mathematically gifted were superior to IQ matched control group in visual congnitive memory.

Sukla and Sharma (1987) conducted a study to find out the level of creativity components in middle school children. The Sample consisted of 230 urban, rural and refuge children. The scientific creativity test was administered to find the level of various creativity components such as fluency, flexibility and originality. It was observed that the rural pupil scored higher fluency than the refuge pupil. It was also found that the lowest scores came from tribal pupil.

Mathew (1986) conducted an investigation into the relationship between adjustment, creativity and achievement in chemistry. The sample consisted of six hundred and sixty secondary school students. The study found that there exist a significant difference between the high achievement group and low achievement group with regards to the variable creativity.

Passi (1982) conducted an experimental study in school children to find out the components of creativity. He found that major creativity components are fluency, flexibility and originality. The study indicates that these creativity components are high level predictors in the solution for all academic achievement and self-concept components.

Joshi (1981) studied creativity and personality traits of intellectually gifted children. It was observed that for urban population high achievers are also highly creative. For the rural population there was no correlation between achievement and creativity.

Badrinath and Sathyanarayana (1979) conducted a correlational study among high school students to find the correlates of creativity. It was found that students of first, second, third and fourth birth order do not differ significantly with respect to their creative scores.

Garber, Resmick, Kepees, and Vedhan (1979) conducted an experimental study to examine the effect of varying home environment in levels of creative thinking. The sample selected for the study includes 155 orthodox and 155 non-orthodox pre-school aged children. Torrance Tests of Creativity Thinking, Figural form A were administered and comparison was made in flexibility, fluency, originality and elaboration. It was found that orthodox subjects were significantly more fluent or productive in their creative thinking and were better able to elaborate on a creative idea than were non-orthodox subjects. Flexibility and originality scores were not significantly different for the groups, suggesting a common overriding developmental theme in these areas. The positive influence of the orthodox family structure is discussed in relation to the high scores on fluency and elaboration obtained by the orthodox group.

Srivastava (1977) conducted a survey study in order to find the relationship between creativity with birth order and number of siblings. The study was conducted on a sample of 543 urban and 354 rural students from standard ten. It was found that birth order of the subjects had no impact on their creativity scores. However, the number of siblings in the family was positively and significantly correlated with creativity scores.

Review of Related Studies on Mathematical Creativity

Midhundas and Vijayakumari (2017) conducted a survey study among secondary school students in order to find out the influence of optimism on Mathematical Creativity. The data was collected from a sample of 100 secondary school students from three schools of Calicut district. Person's product moment coefficient of correlation and test of significance of difference between means for independent groups were used for data analysis. Findings of the study reveal that creativity of the optimist students are significantly higher than that of non-optimist students. The correlational analysis shows that Optimism has a low positive relationship with Mathematical Creativity, Fluency and Flexibility. But the relationship between optimism and originality component of Mathematical Creativity is insignificant.

Tyagi (2017) conducted a correlational study on Mathematical Creativity, mathematical intelligence and the causal relationship between them. Student of age group eleven to fourteen were participated in the study and a sample of four hundred and thirty nine students were selected using the teaching of random clustering. Mathematical Creativity among the students was assessed using the test of Mathematical Creativity developed by Singh (1985). There are five types of activity in the test such as patterns, new relationship, nine-dot areas, subject and similarities. The findings of the study revealed that there is no significant unidirectional causal relationship between Mathematical Creativity and mathematical intelligence. However there exists a symmetric relation between the two variables. It was also found that mathematical intelligence is a cause of Mathematical Creativity and vice versa.

Kanhai and Singh (2016) conducted an experimental study to find whether there exists any causal relation between Mathematical Creativity and mathematical problem solving performance. Sample selected for the study includes 770 seventh grade students. Self concept in mathematics and some environmental and school variables such as Pearson correlation, multiple correlations, regression, analysis of variance, etc. were used for data analysis. There exists a significant positive correlation between Mathematical Creativity and attitudinal and environmental characteristics. The study predicts the influence of attitudinal characteristic-self-concept in determining Mathematical Creativity. Also the environmental factors-resource adequacy, creative stimulation by teachers, etc. were found to be predictors of Mathematical Creativity in the study. Social and intellectual involvement among students and educational administration of schools were found suppressive factors.

Midhundas and Vijayakumari (2016) conducted a correlational study among secondary school students in order to find the influence of Mathematics anxiety on Mathematical Creativity. The study was conducted on a sample of 100 ninth standard students from Calicut district. Pearson’s product moment correlation coefficient was used to analyze data and the findings of the study revealed that there exists a negative linear correlation between Mathematics anxiety and Mathematical Creativity.

Vijitha (2016) conducted a correlational study on the spatial ability and Mathematical creativity among higher secondary school students. The study was conducted on a sample of 281 male and 338 female higher secondary school students. The result of the study revealed that there is significant positive correlation between spatial ability and Mathematical Creativity of higher secondary school students.

A correlational study was conducted by Jaleel and Titus (2015) on relationbetween Mathematical Creativity and Achievement among the secondary school students. The participants of the study were 240 secondary school students from various schools of Thrissur and Ernakulam districts. The correlation was explored using Pearson’s Product Moment coefficient of correlation. The findings of the study revealed a positive correlation between Mathematical Creativity and achievement of secondary school students.

Singer and Voica (2015) studied the mathematical creativity of fourth to sixth grades high achievers in mathematics in relation to their problem posing abilities in geometry. The study found that the students showed a kind of cognitive flexibility which is mathematically specialized. Mathematical Creativity of the students is manifested itself during problem posing contexts through a process of abstraction- generalization based on small, incremental changes of parameters so that synthesis and simplification is achieved.

Betty (2013) conducted a study on Mathematical Creativity and ability for fundamental Mathematical operations of primary school students with dyscalculia. The study was conducted among a sample of 2024 primary school students selected from fifty schools of Ernakulam district. The findings of the study reveals that among the sample 6% students are with dyscalculia and their Mathematical Creativity and ability for fundamental operations differ significantly with that of normal students.

Sebastian (2013) conducted a correlational study among the secondary school students about the relationship between Mathematical Creativity and achievement in Mathematics. The sample selected for the study was 992 secondary school students. Mathematical Creativity test and Achievement test in Mathematics were the tools for data collection. The findings of the study established a significant positive relationship between the two variables Mathematical Creativity and achievement in Mathematics.

Sharma (2013) investigated the effect of divergent mathematical exercises, creativity and their interaction on Mathematical Creativity of the students. The study was of experimental in nature with pre-test post-test control group design. The sample consists of 127 class IX students of age ranging from 14 to 17 belonging to six different schools of Jalandhar district. Moghe test of creative thinking in Mathematics was used for measuring Mathematical Creativity and Passi tests of creativity for measuring creativity. Data were analyzed with the help of 2x2 Analysis of Covariance. The result indicates that divergent mathematical exercises were effective in fostering Mathematical Creativity when groups were matched on pre-test of Mathematical Creativity. Creativity was found to be a significant correlate of Mathematical Creativity. It was also found that Mathematical Creativity was independent of interaction between treatment and creativity when groups were matched with respect to the pre-test.

Bahar and Maker (2011) explored the relationship between Mathematical Creativity and Mathematical achievement. In the study students' score in Mathematics was correlated with 'Iowa Test of Basic Skills' (ITBS) and the 'Comprehensive Tests of Basic Skills' (CTBS). ITBS included measures of problem solving, data interpretation, Mathematics concepts, estimation and computation. The CTBS was used as a measure of Mathematical achievement in Mathematical concepts, estimation and computation. It was concluded that there exists a positive and significant correlation between Mathematical Creativity and its components-originality, fluency, flexibility, elaboration-with Mathematical achievement in both ITBS and CTBS tests.

Nisha (2010) investigated the influence of commercialized learning materials for the development of creativity in Mathematics in secondary school students. The participants of the study were 607 secondary school students and 31 Mathematics teachers from 7 districts in Kerala state. The findings of the study revealed that even though opportunities and environment for the development of Mathematical Creativity was provided, the utilization of commercialized learning materials acted as a barrier for the development of creativity in Mathematics in secondary school students.

The relationship between Mathematical Creativity and Achievement in Mathematics was examined by Talawar and Madhusudhanan (2010). The participants were six hundred students of different English medium schools in Bangalore. The results indicate that there is a significant positive relationship between Mathematical Creativity and achievement in Mathematics.

Kavitha (2009) investigated the interaction effect of Mathematical Creativity, intelligence and problem solving ability on achievement in Mathematics of ninth standard students of Banglore District. The participants of the study were 600 ninth standard students in Banglore district from different types of English medium schools. The result of the study establishes a positive relationship between Mathematical Creativity and Achievement in Mathematics.

Leikin and Lev (2007) conducted a study in school children and introduced multiple solution tasks as a tool for measuring Mathematical Creativity. Students from three ability groups – Gifted, Proficient (non-gifted), and Regular were asked to solve problems in different ways. Non-gifted proficient students and their gifted peers differed in solutions of the non-conventional task but manifested similar results when dealing with the conventional one. Students from these two groups differed meaningfully in all parameters from regular students.

A correlational study was conducted by Sreerekha (2001) to find out the relationship between self-concept intelligence and Mathematical Creativity in secondary school. The tools used for the study were test on Mathematical Creativity, scale on self-concept and Intelligence test using Raven’s coloured progressive matrices. The findings of the study revealed that both intelligence and Mathematical Creativity have significant positive correlation with Mathematics achievement.

Haylock (1997) conducted a study among secondary school students for recognizing Mathematical Creativity. It was found that students with similar degree of mathematical achievement have significant differences in Mathematical Creativity and mathematical ability. This result implies that several factors differentiate Mathematical Creativity from mathematical ability in general.

Resmi (1997) investigated the interaction effect of Mathematics study Approach and Mathematical Creativity on Achievement in Mathematics of secondary school pupil in Kerala. The participants of the study were 600 ninth standard students from three districts. Test of Mathematical Creativity, Mathematics study Approach and Achievement test in Mathematics were used for collection of data. Findings of the study revealed that Mathematics study approach has no positive correlation with Achievement in Mathematics.

However there exists a significant positive correlation between Mathematical Creativity and Achievement in Mathematics.

George (1994) conducted a study on the Mathematical Creativity of secondary school students in relation to their intelligence and mathematical achievement. The sample includes 8000 secondary school students. It was found that there exists a significant and positive correlation between Mathematics creativity and Mathematics achievement.

Haylock (1987) studied the aspects of Mathematical Creativity among children of age of eleven to twelve. It was reported that children may show a fixation in Mathematics and the fixation may provide some self restriction that may cause them to fail to solve problems. He suggested that mathematical attainment limits the pupil's creativity but does not determine it. Low attaining pupils who do not have sufficient mathematical knowledge and skills demonstrate creative thinking. In highest attaining group there is significant number of pupils who show very low level of these kinds of creative thinking in Mathematics.

Tuli (1980) conducted a correlational study among school students for studying studied Mathematical Creativity in relation to aptitude for achievement in mathematics. It was found that Mathematical Creativity is significantly correlated to aptitude and achievement in Mathematics.

Jensen (1973) conducted a study on the relationships among Mathematical Creativity, numerical aptitude and mathematical achievement. It was recommended that the possibility of Mathematical Creativity as a supplementary evidence for student's Mathematics performance. It was found that moderately high correlation among the constructs Mathematical Creativity, numerical aptitude and mathematical achievement.

Various studies conducted on Creativity (after 2000), the investigator, year and major findings are listed below in table 21 and that on Mathematical Creativity in table 22.

Table 21

Details of Various Studies on Creativity

Investigator	**Year**	**Major findings**
Moltafet, Firoozabadi and Raisi	2018	Parenting style and basic psychological needs influence the emotional creativity of the learners.
Daunis and Scullin	2017	Normal sleepers scored higher in creativity tests and microeconomics tests than that of short and long sleepers.
Yeh and Lin	2017	Motivation for achieving both mastery goals and performance goal is crucial for enhancing self- efficacy and achieving mastery experience in creativity.

Kim, Park, Yoo and Kim	2016	Creative proficiency improved with the adoption of the instrumental model for tablet-based interactive classrooms.
Liu, Lu, Wu and Tsai	2016	Students who experienced the peer review using a set of storytelling rubrics produced significantly more sophisticated stories than those who did not.
Varghese	2016	Appreciation and creativity in English poetry has significantly enhanced by Educational courseware among secondary school students.
Yeh and Lin	2015	The e- learning website and the online experimental system developed in php and java script is effective and improving the participants' creativity.
Smogorzewske	2014	Storyline' and "Association pyramid" methods are effective for developing language creativity among kindergarten children.
Topno	2014	Emotional intelligence and creativity are inseparable dimensions to measure the effectiveness of teachers practicing at schools.
Anjali	2013	There is a positive influence for the play school on the behavioral profile, creativity, problem solving ability and social cognition of the preschoolers.

Jayaram	2013	Professional qualifications and teaching experience of teachers do not make any differences in creativity scores of the students.
Kuveri	2013	Concept mapping is highly effective in developing scientific creativity.
Singh	2013	Creativity has no direct influence on academic achievement.
Gupta	2012	There is no significant difference in intelligence and creativity with respect to gender. But creativity varied significantly due to parental education and locality of residence.
Rao	2012	Students of Navodaya schools are better in their Scientific Creativity level than that of private students.
Rawat and Kumar	2012	The elementary students of Government schools have higher flexibility scores. There is a significant difference in the originality of elementary students related to locality.
Albert and Kormos	2011	All the components of creativity are highly effective on narrative task performance.
Baran, Erdogan, and Cakmak	2011	There is no significant relationship between mathematical ability and creativity. Also there was no significant

		relationship between mathematical ability and creativity components such as fluency, originally and elaboration.
Upadhyaya	2011	There is no significant difference in the creativity level of students at different levels of socio economic status.
Yadav and Wadhwa	2011	There is no impact of creativity on academic achievement. The girls and boys of English medium school possess more creativity and they are good achievers than the girls and boys of Hindi medium schools.
Syh-jong	2010	The student's creativity was motivated by the online inter-activities and the teacher's inquiry. Also there is a need to change student's expression of sensitivity, fluency, flexibility, originality and elaboration of scientific creativities.
Alam	2009	There exists a significant positive correlation between creativity and academic achievement as well as between achievement motivation and academic achievement.
Eunsook, Stephanie and Masy	2009	Creativity fostering instructional practices were not significantly affected by teacher's motivation for challenging work, beliefs about learning and performance goals.

Hilal and Omar	2008	The Scientific Process Skill Education increased the student's achievements and scientific creativity. No meaningful progress was made on their attitudes towards science when compared to the teacher-centered method.
Reddy	2008	Male and female student teachers do not differ significantly with respect to creativity.
Ward	2008	There were links between tested knowledge and the rated practicability of the design.
Kim	2008	Many gifted students were under achievers and up to 30% of high school dropouts would be highly gifted.
Meera and Menon	2008	High intelligent group differed in their creative performance from low intelligent group. It was also found that teaching through Synectics model can influence the creativity of students.
Vasugi and Kalavathy	2008	The scientific creativity of high school students differs significantly with respect to living place, medium of instruction, type of school, educational qualification of parents and income. Also there is a significant positive correlation between scientific creativity and achievement in science.

Charyton	2007	Musicians scored high in general and artistic creativity where no significant difference in scientific creativity was observed between the two groups.
Ismail	2007	Strategies for teaching English used by the investigator have significant effect on nurturing creativity among the higher secondary school students.
Jacob	2007	There is a positive correlation between creativity and self-concept. Here the researcher emphasized the significance of creativity as well as the need for developing good and positive self-concept for fostering creativity.
Aurora and Fuentes	2006	Highly creative individuals achieved low score on psychopathology. It was also found that there is a strong negative correlation between creativity and psychopathology on all sub-scales. Psychopathology was more related to personality than to creativity.
Kaur	2006	There is a significant positive correlation between creativity and home environment. Also children of urban school scored higher on all four aspects of creativity than their rural children. It was found that urban schools were better than rural schools in terms of physical

		facilities, school activities and teacher's behavior.
Sak and Maker	2006	Knowledge has a significant contribution in explaining variance in divergent production abilities such as originality, flexibility and elaboration in fourth and fifth graders.
Chi-Kunag, Bernad and Kuang-yiao	2005	The students, after completing this reformed curriculum program had significantly improved their creativity.
Kurtzberg	2005	Cognitive diversity is beneficial for objective finding. It is affecting the member's creative performance. It is also indicates that creativity is a complex multi-dimensional construct and cognitive diversity is an important predictor of team emotions and outcomes.
Prieto and Sanchez	2005	The result of the study indicated a low correlation between creativity and intelligence.
Hong and Aqui	2004	Creative students in Mathematics were cognitively more resourceful than their peers who achieved high grades in school mathematics. They used more cognitive strategies than the academically gifted. It was also found that creatively talented males showed more effort than academically gifted male students.

Jyothilekshmi	2004	There is no significant difference between the government and private aided girl students with respect to originality but the total creativity of the boys in private aided schools was greater than that of boys in government schools.
Slavica	2004	Results of the study reveal a low positive correlation between creativity and achievement in the sub sample of girls.
Sreekanth	2004	The influence of society in the form of parents, teachers and school administrators should consider the learner-centric, learner-friendly aspects while developing curriculum.
Banerjee and Debasri	2003	There exists a significant positive correlation between cognitive style and self concept with creativity. The factors discriminating between high, moderate and low creative are fluency, verbal and non-verbal elaboration and originality. Cognitive style did not significantly discriminate between creativity groups.
Hu and Adey	2002	Scientific creativity of the secondary school students' increase with increase in age. Scientific ability is a necessary but not sufficient condition for scientific creativity.

Baker and Rudd	2001	Collegiate educational experience has little effect upon the students' ability to be creative and on their dispositions to think critically. Also, critical and creative thinking are not closely connected.

Table 22

Details of Various Studies on Mathematical Creativity

Investigator	**Year**	**Major findings**
Midhundas and Vijayakumari	2017	Creativity of the optimist students are significantly higher than that of non-optimist students. The correlational analysis shows that Optimism has a low positive relationship with Mathematical Creativity, Fluency and Flexibility. But the relationship between optimism and originality component of Mathematical Creativity is insignificant.
Tyagi	2017	There is no significant unidirectional causal relationship between Mathematical Creativity and mathematical intelligence. However there exists a symmetric relation between the two variables. It was also found that mathematical intelligence is a cause of Mathematical Creativity and vice versa.
Kanhai and Singh	2016	There exists a significant positive correlation between Mathematical

		Creativity and attitudinal and environmental characteristics. The study predicts the influence of attitudinal characteristic-self-concept in determining Mathematical Creativity. Also the environmental factors-resource adequacy, creative stimulation by teachers, etc. were found to be predictors of Mathematical Creativity in the study. Social and intellectual involvement among students and educational administration of schools were found suppressive factors.
Midhundas and Vijayakumari	2016	There exists a negative linear correlation between Mathematics anxiety and Mathematical Creativity.
Jaleel and Titus	2015	There is a positive correlation between Mathematical Creativity and achievement of secondary school students.
Betty	2013	Among the sample 6% students are with dyscalculia and their Mathematical Creativity and ability for fundamental operations differ significantly with that of normal students.
Sebastian	2013	There is a significant positive relationship between the two variables Mathematical Creativity and achievement in Mathematics.
Sharma	2013	Divergent mathematical exercises were

		effective in fostering Mathematical Creativity when groups were matched on pre-test of Mathematical Creativity.
Bahar and Maker	2011	There exists a positive and significant correlation between Mathematical Creativity and its components-originality, fluency, flexibility, elaboration-with Mathematical achievement in both ITBS and CTBS tests.
Nisha	2010	Even though opportunities and environment for the development of Mathematical Creativity was provided, the utilization of commercialized learning materials acted as a barrier for the development of creativity in Mathematics in secondary school students.
Talawar and Madhusudhanan	2010	There is a significant positive relationship between Mathematical Creativity and achievement in Mathematics.
Kavitha	2009	There is a positive relationship between Mathematical Creativity and Achievement in Mathematics.
Leikin and Lev	2007	Non-gifted proficient students and their gifted peers differed in solutions of the non-conventional task but manifested similar results when dealing with the conventional one. Students from these two groups differed meaningfully in all

		parameters from regular students.
Sreerekha	2001	Both intelligence and Mathematical Creativity have significant positive correlation with Mathematics achievement.
Haylock	1997	Several factors differentiate Mathematical Creativity from mathematical ability in general.
Resmi	1997	Mathematics study approach has no positive correlation with Achievement in Mathematics. However there exists a significant positive correlation between Mathematical Creativity and Achievement in Mathematics.
George	1994	There exists a significant and positive correlation between Mathematics creativity and Mathematics achievement.
Haylock	1987	Children may show a fixation in Mathematics and the fixation may provide some self restriction that may cause them to fail to solve problems.
Tuli	1980	Mathematical Creativity is significantly correlated to aptitude for achievement in Mathematics.
Jensen	1973	Moderately high correlation among the constructs Mathematical Creativity, numerical aptitude and mathematical achievement.

Conclusion

The investigator has made an attempt to review studies in the area of Creativity, especially Mathematical Creativity in India and abroad in an exhaustive way. The review helped the investigator to arrive at a conclusion that many studies in Creativity and Mathematical Creativity are done in India as well as outside India. But Indian studies mainly focus on the relationship of Creativity with other variables (Moltafet, Firoozabadi and Raisi, 2018; Topno, 2014; Jayaram, 2013; Singh, 2013; Yadhav & Wadhva, 2013 & Alam, 2009). Many studies are found to be reported on the relationship of Mathematical Creativity with factors like mathematical anxiety, numerical aptitude, educational administration, intellectual involvement, social involvement, self-concept etc.(Kanhai, 2016; Midhundas & Vijayajumari, 2016; Tuli, 1980 & Jensen, 1973) A number of studies in the area of Mathematical Creativity are on its relationship with achievement in mathematics (Jaleel & Titus, 2015; Sebastian, 2013, Bahar & Maker, 2011; Talawar & Madhusudhan, 2010; Kavitha, 2009 & Sreerekha, 2001). Some studies especially outside India focused on certain strategies like concept mapping, educational courseware, and commercialized learning materials' to develop divergent thinking and Mathematical Creativity (Daunis and Scullin, 2017; Varghese, 2016; Yeh and Lin, 2015; Smogorzewske, 2014; Kuveri, 2013; Sharma, 2013; Albert & Kormos, 2011; Leikin & Lev, 2007 & Haylock, 1997). No studies in Kerala are found to be reported on development of Mathematical Creativity and hence the significance of the present study which attempts to develop a Package on the basics of Geometry with multi-sensory approach, activities, puzzles, games etc. so that young children of age ten to thirteen can develop their ability to think flexibly, originally and give details on the new ideas they arrive at in a mathematical context.

Chapter III

METHODOLOGY

- ***Design of the Study***
- ***Variables***
- ***Participants***
- ***Instruments used***
- ***Procedure of Data Collection***
- ***Scoring and Consolidation of Data***
- ***Statistical Techniques***

METHODOLOGY

Methodology is the technique or procedure used by the investigator for conducting the investigation. It occupies a very important and unique place in a research process. Methodology identifies the entire research plan. Testing of formulated hypotheses for the study requires selection of appropriate design, preparation and selection of valid and appropriate tools, collection of relevant data and the statistical procedures. The present study is to develop a package for fostering Mathematical Creativity and to find out its effectiveness among upper primary school students. The methodology of the study is described under the following major headings

1. Design of the study
2. Variables
3. Participants
4. Instruments
5. Procedure of Data Collection
6. Statistical Techniques used

Design of the Study

The design of the study is quasi-experimental in which experimental and control groups are formed not by assigning individuals randomly. Instead of random assignment of individuals to experimental and control groups, two classes, one each from sixth and seventh standards from two Government schools of Thrissur distinct were selected randomly. Group of students from one school was randomly taken as experimental group and the other as control group. A pre-test on Mathematical Creativity and Raven's colored 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.

The pre-test scores on Mathematical Creativity and its components of the two groups were compared to know whether the two groups are equal in their entry level, so that ceiling effect in the experiment can be controlled. The two schools were selected from Government sector, of the same type of locality and of same performance standard, so that the internal validity of the experiment can be ensured to some extent.

Successive tests on Mathematical Creativity were administered to the experimental group after each module. The design of the study is illustrated as figure 12.

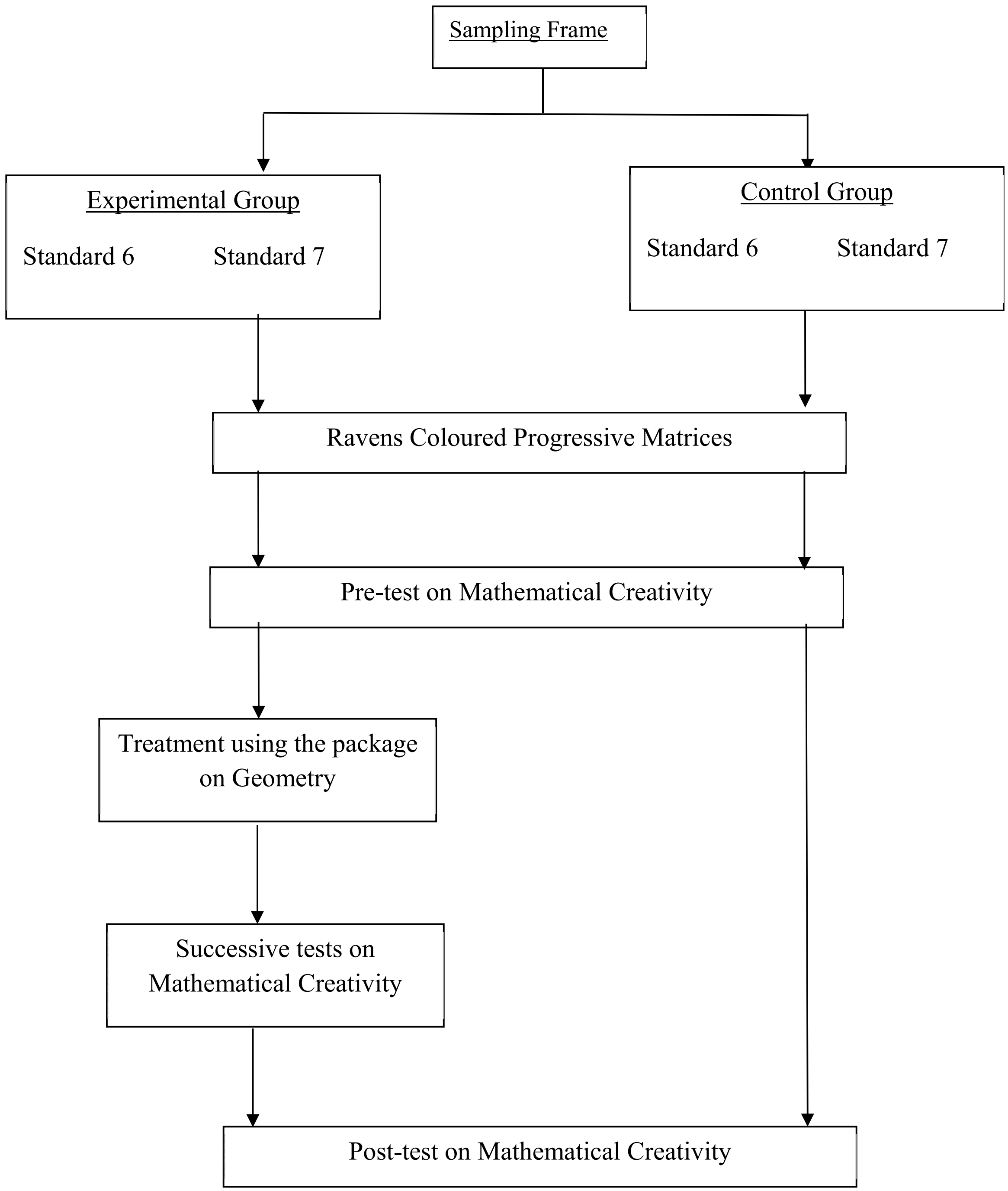


Figure 12. Design of the study

Variables

Variables are the conditions or characteristics that the experimenter manipulates, controls or observes. The variables selected for the study are described below.

Independent Variable

An independent variable is an attribute or characteristic that influences an outcome or dependent variable. It can be a measured variable or a treatment variable which can be manipulated by the researcher. 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 presence and absence of the Package on Geometry are the two levels of the treatment. In the present study the use of the 'Package on Geometry' is the treatment variable, using which a positive change is expected on the experimental group.

Dependent Variable

Dependent variable is a particular behavioral effect of manipulation of the independent variable. It is that characteristic which the experimenter tries to change.

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. It is the total of the scores on Fluency, Flexibility, Originality and Elaboration obtained by a respondent in the test of Mathematical Creativity.

Covariates

Covariates are those variables which are related to the dependent variable but not to the independent variable and can be controlled using statistical techniques.

Creativity is influenced by many factors-both personal and environmental. Personal factors like intelligence, self-concept, anxiety, aptitude etc. are found to be influencing creativity (Sebastian, 2013; Bahar & Maker, 2011; Baran, Erdogan, & Cakmak, 2011; Jacob, 2007). Environmental factors like learner friendly classroom, teacher motivation, beliefs etc. are also found to be contributing to creativity (Moltafet, Firoozabadi & Raisi, 2018; Gupta, 2012; Eunsook, Stephanie & Masy, 2009; Kaur, 2006).

Hence Intelligence as measured by CPM and pre-test score on Mathematical Creativity were taken as covariates whose influences are controlled by using analysis of co-variance.

Participants

The population for which the module is intended is upper primary school students of Kerala state. According to Piaget's theory (Piaget,1926), abstract thinking starts at 11-12 years and hence sixth and seventh standard school students were selected as the sampling frame. Two Government schools from Thrissur district having the same type of locality- rural- and approximately equal level of performance were selected.

From each school, two intact classes, one from sixth and the other from seventh standards were selected randomly in order to avoid complication in conducting the experiment. From these two sets of classes, one is randomly assigned as experimental group and the other as control group. The sampling procedure is presented as figure 13.

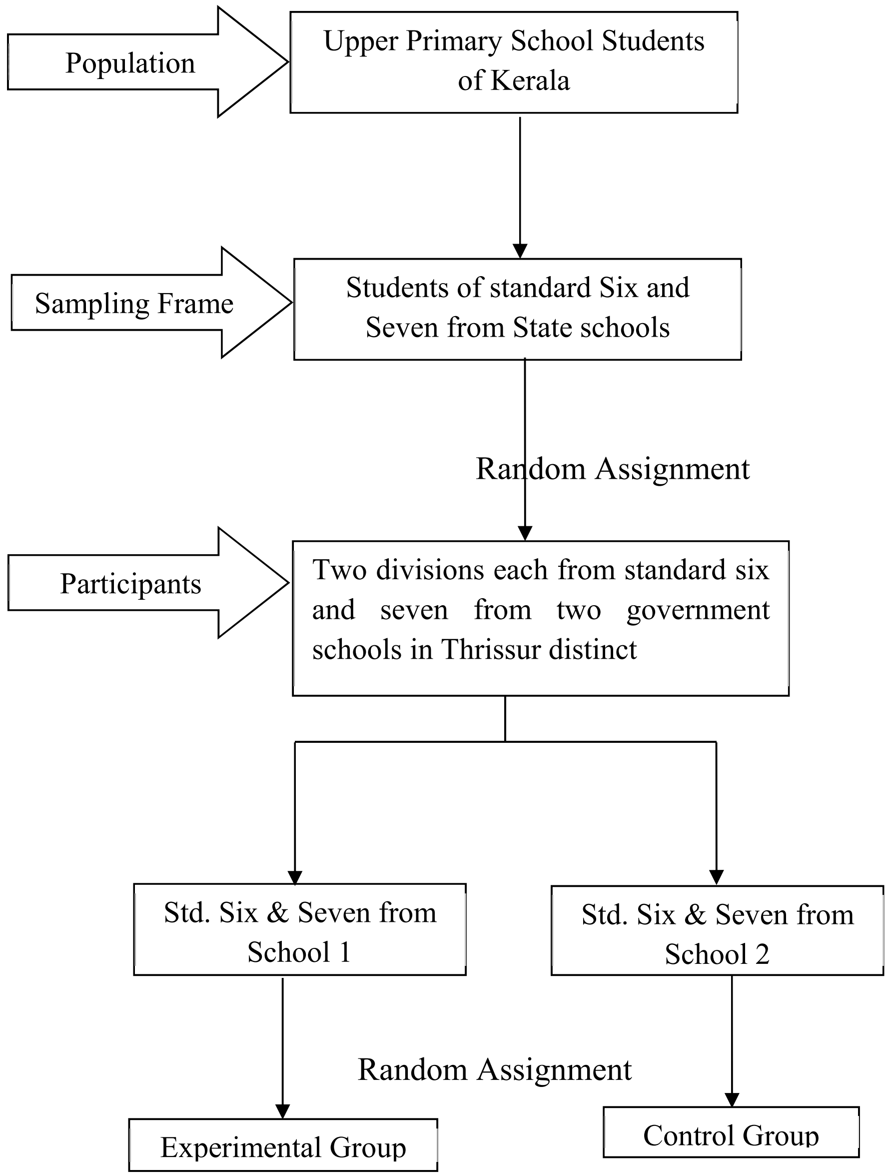


Figure 13. Sampling Design

For standardizing the tests on Mathematical Creativity, a sample of 250 students from eight schools of Thrissur district were selected by stratified sampling method. Details of participants for the experiment and for the pilot study are given as Appendix A_1 and A_2 respectively

Instruments

All types of research need certain instruments to gather new facts or to explore new fields. Selection of suitable instruments or tools is of vital importance in every research study. Three instruments were used for the present study. They are

1. Raven's Coloured Progressive Matrices (CPM)
2. Tests of Mathematical Creativity
3. Rating Scale on various aspects of the package
4. Package on Geometry

Details of these instruments are described below.

Raven's Coloured Progressive Matrices (CPM)

The investigator administered Raven's Coloured Progressive Matrices (CPM) for measuring Intelligence of the learners (Raven, 1995). This test can be satisfactorily used on young children of any language base because of its non-verbal nature.

The test covers cognitive processes of which children under eleven years of age are usually capable. CPM is an individual test with three sets A, Ab and B. Each set consists of twelve problems which constitutes thirty six items in total. Specimen copy of each set is attached as Appendix B.

Scoring of CPM

The Coloured Progressive Matrices measuring Intelligence of the participants in the study was scored by giving 'One' mark for each correct answer and zero for incorrect one. As there are three sets of twelve items in each, an individual can score a maximum of thirty six and a minimum of zero in the test.

The three types of items within CPM are analogy for abstract reasoning, pattern completion through identity and closure and simple pattern completion. The items are printed in the form of bold patterns with brightly coloured grounds.

Reliability

The test manual of CPM declares that the CPM has extremely satisfactory level of reliability assessed by split-half and test-retest methods. The test–retest reliability of CPM ranges from .80 to .90. The split-half reliability coefficient of CPM is found to be varying between .82 and .87 for children of age group 5 to 10 ½ years.

Validity

The test manual says that the concurrent validity of the test is established by correlating the scores with that of the WISC ($r = .91$) and the Primary Mental Ability Test ($r = .55$). The internal consistency coefficients are reported to be from .71 to .90.

Tests of Mathematical Creativity

Creativity means coming up with something novel and useful. Different approaches to measurement of Creativity exist among which that of Torrance and Guilford are more appreciable.

The investigator adopted Torrance approach to Creativity for measuring Mathematical Creativity which is based on Fluency, Flexibility, Originality and Elaboration. In the present study Mathematical Creativity is the dependent variable which measured using the test of Mathematical Creativity. As there was no appropriate tool available to measure Mathematical Creativity in the area of Geometry for upper primary school students, two tests on Mathematical Creativity were developed and standardized by the investigator. Each component (dimension on Creativity) considered in the test is described below.

Fluency

Fluency means the ability to come up with many diverse ideas quickly. It is the number of relevant and acceptable responses.

Flexibility

Flexibility is the number of different categories of responses. It indicates how many ways an individual respond to a particular stimulus. It is an indicative of the individual's ability to respond to a similar situation, to think in a different mode and trying the unknown.

Originality

Originality is the ability to produce rare or uncommon responses, remote associations or connections. It is measured as their infrequency of occurrence or novelty of ideas generated among the participants under study.

Elaboration

Elaboration means the amount of details associated with an idea. It makes the production of detailed steps, variety of implications and consequences. It is the ability to develop ideas and fill them out with details.

The procedure of construction of tests on Mathematical Creativity is given below.

Writing of items

After finalizing the approach to measurement of Creativity, the investigator reviewed various tests on Mathematical Creativity. Similar items from the area of Geometry were written and edited with the help of the supervising teacher. Then the items were scrutinized by experts in the field of Mathematics education and research.

Thus the draft tests were prepared with ten items of almost same nature in both tests.

Try out

The two tests were given to ten students of upper primary level to know whether the items could be easily understood by the students. Items with difficulty in understanding were modified and then two draft tests were ready for pilot testing. The time needed for each item was estimated and included in the test.

The draft of pre-test is given as Appendix C and that of post-test is given as Appendix D.

Pilot testing

The two tests were administered on a sample of 250 upper primary school students of standard six and seven from four schools of Thrissur and Palakkad revenue districts. The sample was selected using stratified sampling method, giving equal weightage to type of management of the schools, and gender of students. The purpose of pilot testing is to collect data for item analysis. The two tests were administered one at a time. Instructions were given clearly and model questions were illustrated. The two tests were administered among students following the time schedule mentioned in the tests. Each test demands 60 minutes for its completion. After the specified time the response sheets were collected back and scored as per the scoring procedure.

Item analysis

Item analysis is a powerful tool to ensure that questions are of an appropriate standard and to select items for inclusion in the test.

Item analysis of both pre-test and post-test on Mathematical Creativity was done separately. On the basis of scores obtained, the response sheets of each test were arranged in descending order. Then the score sheets in the upper 27 percentage and lower 27 percentage were taken as high and low groups respectively. Mean and standard deviation of each item were calculated for both high and low groups. Then't' value of each item was calculated for both pre-test and post-test using the formula.

$t = \frac{M_1 - M_2}{\sigma_D}$ (Garrett, 2004)

where M_1 is the mean score on Mathematical Creativity obtained for an item for the high group, M_2 is the mean score on Mathematical Creativity obtained for an item for low group, $\sigma_D = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$

σ_1 is the standard deviation of the distribution of Mathematical Creativity score for an item for upper group and σ_2 is the standard deviation of the distribution of Mathematical Creativity score for an item for low group. After calculating critical ratio, items having critical ratio greater than or equal to 4 were included in the final tests.

The details of item analysis of pre-test on Mathematical Creativity are given as table 23 and post-test on Mathematical Creativity is given as table 24.

Table 23

Details of Item Analysis of Pre-test on Mathematical Creativity

Item No.	**M_1**	**M_2**	**S_1**	**S_2**	**'t' Value**	**Remarks**
1	18.70	10.48	2.83	1.89	12.57**	Accepted
2	15.33	14.00	3.14	3.35	1.51	Rejected
3	20.15	11.63	4.21	2.83	8.72**	Accepted
4	18.93	17.15	2.99	2.77	2.27	Rejected
5	19.78	11.96	2.87	3.20	9.44**	Accepted
6	21.52	12.26	3.49	2.89	10.62**	Accepted
7	16.74	14.56	4.43	3.42	2.03	Rejected
8	21.52	13.11	3.33	3.37	9.22**	Accepted
9	17.67	14.59	4.07	3.51	2.97	Rejected
10	21.52	12.96	4.40	2.97	8.38**	Accepted

Table 24

Details of Item Analysis of Post-test on Mathematical Creativity

Item No.	M_1	M_2	S_1	S_2	't' Value	Remarks
1	18.63	12.07	2.73	2.51	9.18**	Accepted
2	19.26	14.00	3.64	3.35	5.52**	Accepted
3	16.44	15.78	2.33	2.49	1.02	Rejected
4	18.56	16.70	2.42	2.52	2.75	Rejected
5	19.04	12.85	2.33	2.55	9.30**	Accepted
6	19.33	13.92	2.08	2.27	9.13**	Accepted
7	16.67	15.00	2.83	2.89	2.14	Rejected
8	17.15	15.26	2.78	1.99	2.87	Rejected
9	18.93	12.15	3.14	2.41	8.90**	Accepted
10	20.48	11.85	3.30	2.30	11.16**	Accepted

Thus four items were rejected from the draft of pre-test on Mathematical Creativity and the final test has six items. In the draft of post- test on Mathematical Creativity also, four items were rejected and the final test has six items. A copy of the final pre-test on Mathematical Creativity is given as Appendix E and post-test on Mathematical Creativity is as Appendix F.

Reliability

Reliability is the degree of consistency that the instrument demonstrates. The value of Cronbach α obtained for pre-test is .89 and .84 for post-test. Hence both pre-test and post-test on Mathematical Creativity are reliable.

Validity

An index of validity refers to the degree to which evidence and theory support interpretation of test scores. The test has content validity as it was prepared after thorough analysis of the content area. The tests have face validity as the investigator has consulted experts in the field of Mathematics education at various stages of its construction. The suggestions of experts were incorporated before finalization of the tests on Mathematical Creativity. Both the tests have criterion related validity and the external criterion chosen was scores on Mathematical Creativity Test developed by Sumangala (1987). For this the tests were administered on a sample of 30 students. After administration, the score sheets were scored and the correlation coefficient for the scores on pre-test and the external criterion as well as that of post-test and the external criterion were calculated.

The correlation coefficient obtained for pre-test is .79 and hence the pre-test on Mathematical Creativity is valid to measure Mathematical Creativity among upper primary school students.

The correlation coefficient obtained for post-test is .66 and hence the post-test on Mathematical Creativity is valid to measure Mathematical Creativity among upper primary school students.

Scoring Procedure

The responses on the test items are to be scored for components of Mathematical Creativity viz., Fluency, Flexibility, Originality and Elaboration. The scoring procedure of each component is described below.

Scoring Procedure of Fluency

The number of correct responses is accounted for Fluency. For each item, the correct response excluding those repeated in an identical form are counted and each response is assigned score 'One'. The total score on Fluency of a student is the sum of Fluency scores he/she received in all the items on the test.

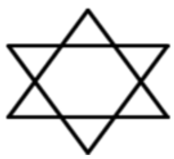
Example: Form as many meaningful shapes using triangles of any size. Also name them.

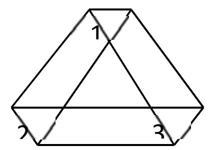
The above response gets a Fluency score 'one' as it includes triangles.

Scoring Procedure of Flexibility

Flexibility refers to the variety of responses to a given situation. This captures the ability to cross boundaries and makes remote associations and is measured by number of different categories of ideas generated. It is a matter of fluidity of information or a lack of rigidity. Flexibility is the basis of originality, ingenuity and inventiveness.

Example: Form as many meaningful shapes using triangles of any size. Also name them.





The above responses get Flexibility score 'two' as both of them are of different categories.

Scoring Procedure of Originality

Originality measures the number of original response or uncommonness of the response. All the responses are listed and tally marks are put against it for the number of students wrote that response. Response that is given by less than 5 percentage has given Originality score as 5 marks, less than 10 percentage as 4 marks, less than 15 percentage as 3 marks, less than 20 percentage as 2 marks and less than 25 percentage as 1 mark. Response marked by 25 percentage or more students is not considered as a rare one and no score on Originality is given. The total score obtained by the individual for all the items in the test is his/her Originality score. The scoring procedure reveals that there is no maximum mark for

Originality and the minimum score is zero. The scoring procedure of Originality in the test of Mathematical Creativity is given in table 25.

Table 25

Scoring Procedure for Originality in the Test of Mathematical Creativity

No.	Grouping in terms of uncommonness of response	Scores
1	Response given by less than 5% students	5
2	Response given by less than 10% students	4
3	Response given by less than 15% students	3
4	Response given by less than 20% students	2
5	Response given by less than 25% students	1
6	Response given by more than 25% students	0

Example: Form as many meaningful shapes using triangles of any size. Also name them.

If 12% students have drawn star as the response for the above question, each of them get Originality score as 'three' for this particular item.

Scoring Procedure of Elaboration

Elaboration measures the amount of details associated with the idea. Elaboration has more to do with focusing on each solution or idea and developing it further. It is a facility for adding a variety of details or developing the response that has already been produced. These are implications to be followed up and finishing touches to be added in order to round out the final product.

Example: Form as many meaningful shapes using triangles of any size. Also name them.

If the student has drawn and labeled the figure as 'star', he/she gets Elaboration score as 'one' as it is meaningful.

Scoring Procedure of Mathematical Creativity

Mathematical Creativity of the participants was taken as the sum total of the scores on its components. In the present study the components of Mathematical Creativity considered were Fluency, Flexibility, Originality and Elaboration. Hence Mathematical Creativity of each individual is the sum total of scores obtained in Fluency, Flexibility, Originality and Elaboration.

Rating Scale on Various Aspects of the Package

The investigator prepared a rating scale for validating the Package on Geometry among teachers. Through this rating scale, twelve aspects of the modules prepared are rated and reviewed such as appropriateness, practicality, comprehensiveness, simplicity, student friendliness, systematization etc. The capability of the modules in terms of production and nourishment of the components of Mathematical Creativity viz., Fluency, Flexibility, Originality and Elaboration are also rated. The rating of the module was done in three point scale with levels as low, average and high.

Package on Geometry

A package on Geometry was developed, focusing on the development of creative thinking among students. A modular approach was adopted and the package comprised of eight distinct modules on various topics in Basic Geometry of upper primary level.

A module is a self-contained unit with a definite set of expected behavioral outcomes, providing a series of learning experiences resulting into the learning of a concept or a problem solving (Wiles & Bonondi, 1989).

Basic steps involved in the construction of the package are described under the following heads.

1. Selection of content

2. Allocation of content into various modules

3. Preparation of Modules

Selection of the Content

For developing the package on Geometry, the investigator analyzed text books of standard five, six and seven from various syllabi such as SCERT, NCERT and ICSE. Other resource books and online materials were also referred, so that relevant content of Geometry can be identified. The basic ideas on Geometry selected for the package are point, line, line-segment, ray, plane, curves, angles, measurement of angles, pair of straight lines, angle between pair of straight lines, polygons, triangle, rectangle, square, circles, symmetry, congruency, similarity and three dimensional Geometry.

Allocation of Content into Various Modules

The identified Geometric content at upper primary level were organized into eight distinct modules. Each module was subdivided into two or three sub modules for convenience of transaction. Each sub module is designed in such a way that, it can be completed by 45 minutes and almost equal amount of task is assigned in each. Allocation of Geometrical content into various modules is given as table 26.

Table 26

Details of Allocation of Geometrical Contents into Various Modules

Module	**Sub module**	
M_1 Basic Structures	SM1	Point, line and Plane
	SM2	Line, ray & line-segment
	SM3	Plane and curved surfaces
M_2 Angles	SM1	Angles
	SM2	Measurement of angles
	SM3	Pair of straight lines and angle between them
M_3 Geometrical Shapes	SM1	Curves
	SM2	Polygons
M_4 Similarity, Congruency and symmetry	SM1	Similarity
	SM2	Congruency
	SM3	Symmetrical shapes
M_5 Triangles	SM1	Triangles
	SM2	Types of triangles
	SM3	Properties of triangles
M_6 Quadrilaterals	SM1	Types of quadrilaterals
	SM2	Area of square and rectangle
M_7 Circles	SM1	The concept of circle
	SM2	Circumference of circle
M_8 Three dimensional Geometry	SM1	Identification
	SM2	Classification

Preparation of Modules

After allocating content into various modules, the investigator followed the principles and steps recommended by Chanrill (1982) for preparing the modules. Each module is distinct, self-explanatory and is divided into small divisions as sub modules. In each module the objectives are mentioned. Then the content to be transacted is described. In each sub module, the content is introduced and concepts are transacted using various methods such as narration, animation, power point, creative games, activities etc. After a creative activity related to the content, a puzzle or game was given to maintain interest in learning and sustain motivation. After that each sub module is given with a home assignment at the end. Also, at the end of each distinct module of two or three sub modules, a Module–test of three items from the related content was administered to the participants. In the module test, each item measures four components of Mathematical Creativity viz., Fluency, Flexibility, Originality and Elaboration.

Details of modules, sub-modules, objectives, activities and test items in the module tests are given as table 27.

Table 27

Details of Modules and Activities in the Package on Geometry

Sub-Module	Objective	Content, Transaction method	Activity	Test Item
MODULE I - BASIC STRUCTURES				
Submodule:1. Point Line Plane	1. To make the learner know about point, line and plane. 2. To enable the learner understand the relation of point with line and plane. 3. To enable the learner apply the knowledge of points, line and plane in solving puzzles. 4. To analyze situations where the concepts of points, line and plane are involved.	1. Point: Power point presentation 2. Scattered points: Power point presentation 3. Line: Animation 4. Plane: Animation	Each student is given with a card with marked points arranged in rows and columns at a distance 1 cm each. Students are asked to join the given points for making various figures and name them each.	1. Draw as many patterns as you can with the theme, 'From a point as centre' and name the figures you have drawn. 2. Find examples from your surroundings for point, line, line-segment, ray etc. Point: bindi

	5. To judge the appropriateness of using points, lines and planes at particular situations. 6. To develop creative responses for activities involving points, lines and planes.	5.Relation between point, line and plane: Animation		Line: railway line Line-segment: edge of a scale Ray: beam of a torch light
Submodule:2 Line Ray Line-Segment	1. To enable the learner know about line-segment, ray and line. 2. To enable the learner understand the relation of line-segment, ray and line. 3. To enable the learner apply the knowledge of line-segment, ray and line in solving puzzles. 4. To analyze situations where the concepts of line-segment, ray and line can be used. 5. To judge the appropriateness of using line-segment, ray and line at particular situations.	1. Line: picture 2. Ray: Animation 3.Line-segment: Animation	In this activity, line-segments are made without using scale. The items needed for this activity are a paper and colour pen. Fold the given paper to form line-segments and mark them using colour pen. Make as many such line-segments as possible.	3. Draw a theme based figure and mark all the shapes you know with special emphasis on plane and curved surface.

	6. To develop creative responses for activities involving line-segment, ray and line.			
Submodule:3 Plane surfaces Curved surfaces	1. To make the learner know about plane and curved surfaces. 2. To understand the features of plane and curved surfaces. 3. To enable the learner apply the concepts of plane and curved surfaces in solving puzzles. 4. To analyze situations where the concepts of plane and curved surfaces are involved. 5. To judge the appropriateness of using plane and curved surfaces at particular situations. 6. To develop creative responses for activities related to plane and curved surfaces.	1.Plane surfaces: Direct experience, Power point presentation 2.Curved surfaces: Direct experience, Power point presentation	Identify the surfaces where straight lines and curves can be drawn and surfaces where only curves can be drawn. The teacher shows some objects two at a time and asks the students to differentiate them (with their properties) a)a foot ball and a piece of card board	

			b)a sea shell and a slate c)a pot and a writing pad d)an egg shell and a note book	
MODULE II:ANGLES				
Submodule:1 Angles Measurements	1. To make the learner know about angles, their measurements and types of angles. 2. To enable the learner understand various characteristics of angles, their measurements and types of angles. 3. To analyze the situations where the concept of angles are involved.	1.Arms and vertex of an angle : Animation 2.Measurement of angles: Animation 3.Types of angles a. Right Angle b. Acute Angle c. Obtuse Angle d. Straight Angle	Draw a star on the space below and mark all the possible angles with a colour pencil. Also measure each of them using a protractor.	1. Draw and explain as many angles involved in alphabets. 2. Name as many articles involving parallel and perpendicular lines. Eg: Book shelf has both parallel and perpendicular lines 3. Mark and name all the possible angles on

	4. To judge the appropriateness of using various types of angles. 5. To develop creative responses for activities related to angles and their measurements.	e. Reflex Angle - Power point presentation		the figure of the tree below.
Submodule:2 A pair of straight lines and angle between them	1. To make the learner know about pair of straight lines and angles between them. 2. To enable the learner understand various angles formed between pair of straight lines. 3. To analyze the situations where the concept of pair of straight lines and angles between them can be used. 4. To judge the appropriateness of using angles formed between pair of straight lines at particular situations.	1.Pair of lines: a. Coincident lines: b. Parallel: c. Intersecting: d. Perpendicular: -Animation 2.Types of angles between pair of straight lines: a. Supplementary b. Complementary c. Linear Pair	Draw a theme based picture and identify parallel and perpendicular lines in it.	

	5. To develop creative responses for activities related to the concept of pair of straight lines and angles between them.	d. Vertically Opposite e. Adjacent f. Corresponding g. Co-Interior h. Co-exterior i. Alternate-Interior -Animation		
MODULE III:GEOMETRICAL SHAPES				
Submodule:1 Curves	1. To make the learner familiar with curves and its types. 2. To enable the learner distinguish between simple and complex curves. 3. To enable the learner distinguish between open and closed curves.	1.Simple curves 2.Non-simple curves 3.Open curves 4.Closed curves	The teacher asks students to make various types of curves using colored threads in a paper.	1. Find examples of closed and open curves from surroundings. 2. Select the theme 'children's park' and design it with all the geometric shapes you

	4. To enable the learner locate various types of curves in his/her surroundings. 5. To enable the learner think creatively on the knowledge of curves.	5.Parts of a Curve: -Power point presentations a. Interior b. Exterior c. Boundary		know. (Use as many shapes as you want). 3. Using a semi-circle and a rhombus as compulsory components, design as many objects.
Submodule:2 Types of polygons and their characteristics	1. To make the learner know about polygons. 2. To enable the learner compare the properties of various polygons. 3. To enable the learner apply polygons at particular situations. 4. To judge the appropriateness of polygons at particular situations. 5. To analyze situations where polygons are involved.	1.Polygon: picture Properties of a Polygon: picture 2.Types of Polygons with its properties: a. Triangle b. Quadrilateral c. Pentagon d. Hexagon e. Heptagon	Draw a theme of your choice. Mark all the geometric shapes involved in it.	

	6. To enable the learner use various polygons creatively.	f. Octagon -Power point presentation 3.Concave and convex polygons: Power point presentation 4.Regular and irregular polygon : Power point presentation		
MODULE IV: SIMILARITY, CONGRUENCY AND SYMMETRY				
Sub-module:1 Congruency Similarity	1. To make the learner know about the concept of congruency and similarity. 2. To enable the learner distinguish between congruency and similarity.	1.Congruency and Similarity: Game activity and discussion	Picture of a butterfly is given. Enlarge the shape and draw it in the box given as the example of bee. Find various instances of	1. Taking the given pattern as 'basic frame rub off some parts of it and make various geometric designs. Identify the design with various objects you are familiar with.

	3. To compare the properties of congruency and similarity. 4. To enable the learner apply knowledge of congruency and similarity in solving puzzles. 5. To analyze situations where the concepts of congruency and similarity are involved. 6. To judge the appropriateness of the concepts of congruency and similarity at particular situations. 7. To enable the learner deal with the concepts of congruency and similarity creatively.		congruent shapes from your surroundings.	2. Find articles from your surroundings of the following category. a. Congruent shapes b. Similar shapes 3. Find examples for rotational symmetry from your surroundings.
Sub-module:2 Symmetry	1. To make the learner know about symmetry. 2. To enable the learner identify symmetry in shapes.	1.Symmetry: Animation	Ask the students to find out various shapes and classify them according to	

	3. To enable the learner compare various geometrical shapes for symmetry. 4. To enable the learner distinguish between congruency, similarity and symmetry. 5. To apply the concept of symmetry in solving puzzles. 6.To develop creative responses for activities related to symmetry.	2.Line of Symmetry: Animation 3.Types of Symmetry: Power point presentation .Reflectional symmetry .Rotational symmetry 4.Tessellation (tiling): Power point presentation Differentiate between similarity, congruency and symmetry:	whether they tessellate or not.	

		Brainstorming Session		
MODULE V: TRIANGLES				
Sub-module:1 Triangle and its properties	1.To make the learner know about triangles. 2.To enable the learner understand properties of triangles. 3.To enable the learner understand angle sum property of triangles. 4.To enable the learner apply the triangles in solving puzzles. 5.To enable the learner creatively use angle sum property of triangles at particular situations.	1.Triangle: Power point presentation 2.Angle sum property of Triangle: Animation	Triangle shaped cards are cut, their corner parts are cut and shuffled. The activity is to find the set of three angles of a triangle by applying the angle-sum property.	1.Use nine match sticks and make as many triangles. Also name things you have drawn. 2.Cite examples of articles at public places having triangular shapes in them. Eg. Bridge 3.Construct toys and other playing articles using various types of triangles. Eg. Yacht
Sub-module:2	1. To make the learner know about various types of triangles.	1.Types of Triangles	An individual activity for	

Triangle-types	2. To enable the learner identify types of triangles with their properties. 3. To enable the learner apply knowledge of triangles in solving puzzles. 4. To enable the learner creatively use the concept of triangle at particular situations.	a. Right Triangle b. Obtuse Triangle c. Acute Triangle d. Scalene Triangle e. Isosceles Triangle - Power point presentation	children! Using scissors cut and make as many triangles from the given colour papers. Stick them in a chart paper and measure the six elements of the triangle. Also label them with types and measures.	
MODULE VI:QUADRILATERALS				
Sub-module:1 Types of Quadrilaterals	1. To make the learner know about quadrilaterals. 2. To enable the learner distinguish between various types of quadrilaterals.	1.Quadrilateral -Power point presentation 2.Angle Sum Property of Quadrilateral	The students are grouped and each group is provided with a chart paper and sketch pencils. They are asked to draw	

	3. To enable the learner understand angle sum property of a quadrilateral. 4. To apply the knowledge of square in solving puzzles. 5. To enable the learner use quadrilaterals creatively at particular situations.	-Animation 3.Types of Quadrilaterals a. Trapezium b.Isosceles Trapezium c. Parallelogram d. Rhombus e.Rectangle f.Square - Power point presentation	their school using various types of quadrilaterals Make a flower usin colour papers! Firs make five pape cutting from th colour paper in th shape of a squar Then fold each c them like a kit Then join the kit shaped papers as th petals of a flowe and stick a stra stick for stem.	
Sub-module:2 Rectangle Square	1. To make the learner know about perimeter of a square. 2. To make the learner know about perimeter of a rectangle.	1.Perimeter a. Perimeter of a Square b. Perimeter of a Rectangle	A group activity! Measure the sides of classrooms and various other parts of your school using a	1. Using various quadrilaterals you know, construct useful articles (drawings) and name them.

	3. To make the learner know about area of a square. 4. To make the learner know about area of a rectangle. 5. To enable the learner solve puzzles involving squares. 6. To enable the learner apply area of squares creatively at particular situations.	- Power point presentation 2.Area a. Area of a Square b. Area of a Rectangle - Animation	measuring tape. Mark them in the sketch of your school you already drawn in the previous activity. Now try to find area of various parts of your school such as classrooms, library, laboratory, office, stage etc. Also write scale that you have chosen. Eg: If 10 meter is the actual measurement, it can be reduced for convenience and mark in the	2. Using squares draw any furniture of your choice. 3. Using quadrilaterals design various learning aids. Eg. Letter pad

			sketch by taking 10 centimeters.	
MODULE VII:CIRCLES				
Sub-module:1 Circle– The concept of Circles	1. To make the learner know about the centre and radius of a circle. 2. To make the learner know about the interior and exterior of a circle. 3. To make the learner differentiate between circles and non-circles. 4. To enable the learner apply circles in solving puzzles. 5. To enable the learner use concept of circle creatively at particular situations.	1.Circles -A game -Power point presentation -Interactive session	Activity to find circles and non-circles! A basket full of coloured papers of circular and non circular shapes is given to students. The task is to differentiate circles and non-circles only through folding. Fold the paper continuously three to five times. If the fold exactly coincides, we can conclude that 'if distance	1. Find various instances where patterns of circles are seen in your surroundings. Eg.Circles formed in water surface when stones are thrown. 2. Using circles of various sizes, form as many designs as possible in a paper. Extra drawings (if necessary) are allowed. Name the object you visualized in them. Eg. Floral Design

			from the centre to any point on the curve is a constant, then the curve is called a circle; otherwise not a circle.'	3. Draw a vehicle of your choice and identify circles and parts of circle in it. Eg. Cycle
Sub-module:2 Circle–Properties	1. To make the learner know about diameter. 2. To make the learner know about semi-circle. 3. To enable the learner know about concentric circles. 4. To make the learner know the relationship between sector and arc. 5. To make the learner distinguish between chord and segment. 6. To enable the learner find circumference of circles.	1.Circle-properties a. Chord b. Diameter c. Circumference d. Arc e. Semi-circle f. Sector g. Segment h. Concentric circles - Power point presentation	A group activity for children! Working model of a circle is made by students which can demonstrate all the properties of a circle such as centre, radius, diameter, chord, arc, segment, sector, semi circle etc. The materials needed for	

	7. To enable the learner apply circles in solving puzzles. 8. To enable the learner deal creatively use the concepts of circles and semicircles.		making this model are a piece of card board, a thermocol sheet, threads and needles.	
MODULE VIII :THREE DIMENSIONAL GEOMETRY				
Sub-module:1 Identification of Three Dimensional Figures	1. To make the learner know about three dimensional figures. 2. To enable the learner distinguish between two and three dimensional figures. 3. To make the learner identify characteristics of three dimensional figures. 4. To make the learner apply knowledge of three dimensional figures in solving puzzles. 5. To make the learner create various three dimensional	1.Dimensions a. One dimension b. Two dimension c. Three dimension -Animation -Game -Power point presentation	Two dimensional figures like squares, rectangles and triangles are distributed to group of students. They are asked to place congruent figures as super positioned. Gradually the two dimensional figure transforms	1. Identify various Three Dimensional figures from public places. Eg: Pencil box, chalk, Phone etc. 2.Using various three dimensional figures, make the theme 'My sweet Home' 3.Using three dimensional figures

	figures by assembling two dimensional figures.		to a three dimensional one.	form as many objects as possible and identify them with your household articles. Eg. Vessel
Sub-module:2 Classification of Three Dimensional Figures	1. To make the learner know about various three dimensional figures. 2. To make the learner identify a 3D shape with its corresponding net. 3. To enable the learner apply the concept of three dimensions in solving puzzles. 4. To enable the learner assemble various three dimensional figures and to make it a meaningful entity.	1.Prism a.Rectangular Prism (Cuboid) b. Square Prism c. Cube d. Triangular Prism -Power point presentation 2. Pyramid 3. Cone 4. Cylinder 5. Sphere 6. Hemi-Sphere -Power point presentation	A group activity! From the given colour papers make as many net of three dimensional figures as possible. The group that makes maximum number of net of three dimensional figures is the winner.	

The detailed modules are given as appendix G and a CD is attached.

Validity of the Package

The effectiveness of the Package on Geometry on Mathematical Creativity was analyzed statistically and details are given in the Chapter IV-Analysis. During the construction of the module, suggestions from experts in the field was sought and incorporated in the module. Certificates from two experts are given as Appendix H. After implementation, two mathematics teachers of CMGHSS, Kuttoor, Thrissur, Kerala, where the data collection was executed were asked to complete a rating scale and the responses are given as Appendix I. These two steps during the construction and after implementation helped the investigator to confirm validity of the package constructed and the empirical validity was ensured by testing its effectiveness using quasi experimental design.

Procedure of Data Collection

The investigator sought permission from the heads of the selected schools through formal letter from Principal, Farook Training College, Kozhikode to administer the tests on Mathematical Creativity and implement the Package on Geometry. The schools selected for data collection were GVHSS, Machad, Thrissur, Kerala and CMGHSS, Kuttoor, Thrissur, Kerala, the former as the control group and the latter as the experimental group. Prior arrangements were made for the study. A time schedule was fixed accordingly for the administration of the tool. The experiment was carried out for a period of four months in the academic year

2015-16.

The investigator informed the participants about the nature of the study and tests on Mathematical Creativity. Data collection procedure and purpose of the Package on Geometry were explained. The experimental group was informed that the tests and package are not based on any particular syllabus and no complicated exam procedures involved. The investigator administered Raven's Coloured Progressive Matrices (CPM) and pre-test on Mathematical Creativity for both experimental and control groups. The Package on Geometry was implemented to the experimental group and no special treatment was given to the control group. Formative tests on Mathematical Creativity were administered after each module. Then post test on Mathematical Creativity was administered to both experimental and control groups. After eliminating incomplete sheets and that of those students who were absent for more than ten days a sample of one hundred and forty students, seventy each in experimental and control group was selected. The response sheets were scored as per the respective scoring procedures and data were consolidated in excel format.

A specimen copy of response sheets of pre-test and post-test on Mathematical Creativity and photographs of participation of students in the experimental group are given as Appendix J_1 , J_2 and K respectively.

Statistical Techniques

The data collected was systematically tabulated, consolidated and subjected to suitable statistical analysis. This part deals with a detailed description of statistical techniques employed to test the tenability of the hypothesis formulated for the present study.

Statistical techniques used for the present study are given below.

1. Preliminary Analysis
2. One tailed test of significance of difference between two means for large independent groups
3. One-tailed test of significance of difference between two large dependent groups
4. Two-tailed test of significance of difference between two means for large independent groups
5. Analysis of Covariance (ANCOVA)
6. ANOVA with Repeated Measures
7. The effect size of the treatment variable

Preliminary Analysis

In preliminary analysis, important statistical constants such as arithmetic mean, standard deviation, skewness, kurtosis etc. of the dependent variable – Mathematical Creativity were calculated.

One-Tailed Test of Significance of Difference between two Means for Large Independent Groups

The critical value is calculated by the formula

$t = \frac{M_1 - M_2}{\sigma_D}$ (Garrett, 2004)

Where, M_1 is the mean score of first group, M_2 is the mean score of the second group and σ_D is the standard error which is calculated by the formula,

Standard Error, $\sigma_D = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$

Where σ_1 is the standard deviation of the first group, σ_2 is the standard deviation of the second group, N_1 is the size of first group and N_2 is the size of second group.

One-Tailed Test of Significance of Difference between two Means for Large Dependent Groups

The critical value is calculated by the formula

$t = \frac{M_1 - M_2}{\sigma_D}$ (Garrett, 2004).

Where, M_1 is the mean score of first group, M_2 is the mean score of the second group and σ_D is the standard error which is calculated by the formula,

$$\sigma_D = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2} - 2r\left(\frac{\sigma_1}{\sqrt{N_1}} X \frac{\sigma_2}{\sqrt{N_2}}\right)}$$

Where σ_1 is the standard deviation of the first group, σ_2 is the standard deviation of the second group, N_1 is the size of first group and N_2 is the size of second group, r correlation coefficient between the two sets of scores.

Two-Tailed Test of Significance of Difference between two Means for Large Independent Groups

The critical value is calculated by the formula

$t = \frac{M_1 - M_2}{\sigma_D}$ (Garrett, 2004)

Where, M_1 is the mean score of first group, M_2 is the mean score of the second group and σ_D is the standard error which is calculated by the formula,

$$\sigma_D = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$$

Where σ_1 is the standard deviation of the first group, σ_2 is the standard deviation of the second group, N_1 is the size of first group and N_2 is the size of second group.

Analysis of Covariance (ANCOVA)

In educational experiments, the psychological variables cannot be empirically controlled as in true experiments. However it should be controlled as it exerts its influence on the experimental variable. To control such variables statistically, we use ANCOVA which is not available in ANOVA. To eliminate the confounds and reduce within group error variance, covariates are included in ANOVA and the effects of the independent variable is assessed more accurately. ANCOVA helps us to exert stricter experimental control by taking account of confounding variables to control and partial out the effect of covariate (Field, 2005). If any variables are known to influence the dependent variable being measured, then ANCOVA is ideal to remove the bias of these variables.

ANOVA with Repeated Measures

The term repeated measure is used when the same group of individuals participates in all levels of experiment. Using this statistical technique, the individual difference can be controlled by distributing the same group of individuals at all levels of the experiment and testing variables after each level is completed. It reduces the unsystematic variability in the design and hence provides greater power to detect effects. This method is economical in the sense only a few participants (minimum of 6) are required for verification of results.

The Effect Size of the Treatment Variable

Effect size is a statistic which estimates the magnitude of an effect (Kelley & Preacher, 2012). To calculate the standardized mean difference between two groups, the difference between mean of the two groups is calculated and divided by the standard deviation.

If the two distributions have a common population, homogeneity of variance is assumed and standard deviations are pooled to calculate Cohen's'd'

(Cohen, 1998). If standard deviation differs, homogeneity of variance is violated and pooling the standard deviation is inappropriate and Glass's Δ is calculated (Hedges & Olkin, 1985).

Cohen's'd' = $\frac{M_1 - M_2}{SD_{Pooled}}$

Glass's 'Δ' = $\frac{M_1 - M_2}{SD_{Control}}$

Where, M_1 is the mean Mathematical Creativity of first group and M_2 is the mean Mathematical Creativity of the second group. Also the pooled standard deviation and control standard deviation are calculated using the following formulae.

$SD_{pooled} = \frac{\sqrt{SD_1^2 + SD_2^2}}{2}$

$SD_{control} = \frac{\sqrt{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}}{2}$

Effect size, $r = \frac{d}{\sqrt{d^2 + 4}}$ or $r = \frac{\Delta}{\sqrt{\Delta^2 + 4}}$

where'd' is Cohen's coefficient and 'Δ' is the Glass's coefficient.

The effect of 'Package on Geometry' is very large when the value of 'r' is greater than or equal to .7 and the effect is large when the value of 'r' is greater than or equal to .5. When the value is greater than or equals to .3 the effect is medium and when the value is greater than or equal to .1 the effect is small.

Conclusion

This chapter fundamentally sketches the modus of operandi that was foll A_1 owed when conducting the present study. A clear sketch has been given on the tool development, how the participants were selected, the method through which the data was collected and statistical analysis that was employed. The collected data was subjected to statistical treatment. The detailed description of analysis and interpretation of data is presented in the next chapter.

Chapter IV

ANALYSIS

- ***Preliminary analysis of scores on Mathematical Creativity and its components***
- ***Comparison of mean scores of pre-test on Mathematical Creativity and its components of experimental and control groups***
- ***Comparison of mean scores of post-test on Mathematical Creativity and its components of experimental and control groups***
- ***Comparison of mean scores of pre-test and post-test on Mathematical Creativity and its components of the experimental group***
- ***Comparison of mean scores of pre–test and post-test on Mathematical Creativity and its components of the control group***
- ***Comparison of gain score on Mathematical Creativity and its components of experimental and control groups***
- ***Comparison of mean gain scores with intelligence and pre-test score on Mathematical Creativity as covariates***
- ***Comparison of mean scores of pre-test and successive tests on Mathematical Creativity and its components of the experimental group.***
- ***Effect size of the treatment on scores***

ANALYSIS AND INTERPRETATION OF DATA

After collection of relevant data it needs to be analyzed properly. Analysis and interpretation of data involves drawing conclusions about it, representing it in tables, figures and pictures to summarize it and interpreting the conclusions in words to provide answers to the research questions.

In the present study, the investigator attempts to find the effectiveness of the 'Package on Geometry' in fostering Mathematical Creativity among upper primary school students. Seventy upper primary school students from a government school of Thrissur district was treated as the experimental group and seventy students from another government school of same standard from the same district was treated as the control group. Pre-test and post-test scores on Mathematical Creativity were collected from the experimental and control groups. Their Intelligence scores were also measured using Raven's Colored Progressive Matrices (1995). In between the modules, Mathematical Creativity tests (formative nature) were administered for experimental group.

The collected data was analyzed using appropriate statistical techniques. The details of data analysis and their interpretation are presented in this chapter under the headings

- Preliminary analysis of scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration among upper primary school students
- Comparison of mean scores of pre-test on Mathematical Creativity and its components of experimental and control groups
- Comparison of mean scores of post-test on Mathematical Creativity and its components of experimental and control groups
- Comparison of mean scores of pre-test and post-test on Mathematical Creativity and its components of the experimental group
- Comparison of mean scores of pre–test and post-test on Mathematical Creativity and its components of the control group
- Comparison of mean gain scores on Mathematical Creativity and its components of experimental and control groups
- Comparison of mean gain scores on Mathematical Creativity of experimental and control groups with Intelligence and pre-test score on Mathematical Creativity as covariates
- Comparison of mean scores of pre-test and successive tests on Mathematical Creativity of the experimental group.
- Effect size of the treatment on scores of Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration.

Preliminary Analysis of Mathematical Creativity and its Components among Upper Primary School Students

As preliminary analysis, the extent of Mathematical Creativity and its components among upper primary school students was calculated and normality of the distribution of Mathematical Creativity was tested. The statistical values like Mean, Median, Mode, Standard Deviation, Skewness and Kurtosis were calculated.

Values of Mean and Standard deviation of Mathematical Creativity and its components for the whole group are presented as table 28.

Table 28

Mean and Standard deviation of Mathematical Creativity and its Components among Upper Primary School Students (Pre-test)

Sl. No.	**Variable**	**Mean**	***Sd***
1	Mathematical Creativity	68.46	26.85
2	Fluency	16.25	5.82
3	Flexibility	14.22	4.98
4	Originality	25.43	15.12
5	Elaboration	12.56	5.08

Results and Discussion

Table 28 shows that mean score on Mathematical Creativity of upper primary school students is 68.46 with standard deviation 26.85. The mean score on Fluency is 16.25 with standard deviation 5.82. The mean score on Flexibility is 14.22 with standard deviation 4.98. The mean score on Originality is 25.43 with standard deviation 15.12. The mean score on Elaboration is 12.56 with standard deviation 5.08.

The normality of the distribution of Mathematical Creativity was tested and its details for the entire group are given in table 29.

Table 29

Values of Mean, Standard Deviation, Skewness and Kurtosis of Mathematical Creativity for the Whole Group

Statistic	**Values**
Mean	68.46
S.D	26.85
Skewness	.392
S.E. of Skewness	.205
Z-value (skewness)	1.91
Kurtosis	.602
S.E. of Kurtosis	.407
Z–value (kurtosis)	1.47

From table 29, it can be seen that the mean score on Mathematical Creativity among upper primary school students is 68.46 with standard deviation 26.85. The value of skewness is .392 with standard error .205. The z-value calculated by dividing skewness with its error is 1.91. Since this value is less than 1.96, the deviation from symmetry is not remarkably high. The value of kurtosis is .602 with standard error .407. The z-value calculated by dividing kurtosis with its error is 1.47. Since the value is in between -1.96 and +1.96, it can be concluded that the distribution is approximately meso-kurtic. These results reveal that the distribution of Mathematical Creativity is almost normal.

The histogram, Normal Q-Q plot and De-trended Q-Q plot were drawn for data which are presented as figure 14 to figure 16.

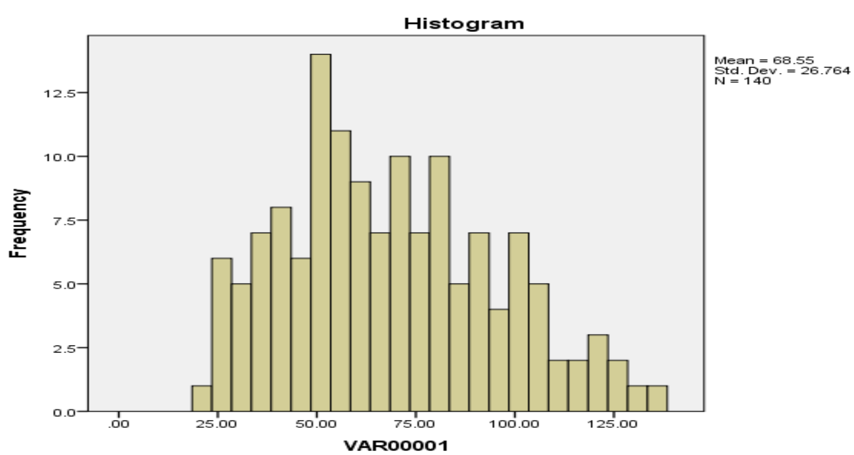


Figure 14: Histogram on the scores of Mathematical Creativity of upper primary school students

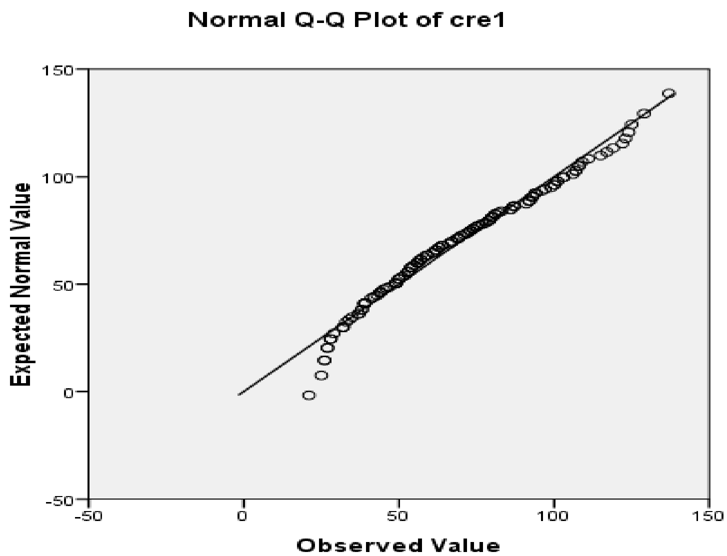


Figure 15: Normal Q-Q Plot on the scores of Mathematical Creativity of upper primary school students

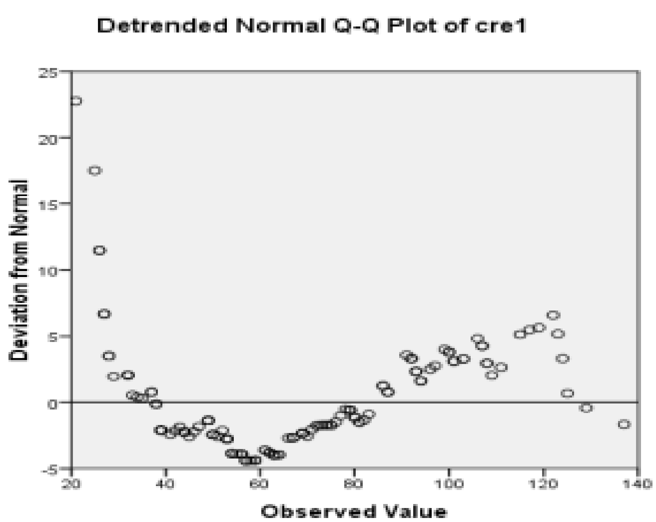


Figure 16: De-trended Q-Q Plot on the scores of Mathematical Creativity of upper primary school students

For the scores on Mathematical Creativity among upper primary school students, the histogram (Figure 14) drawn shows a slight trend to be positively skewed. In the normal Q-Q plot (Figure 15), the values of left are below the line, towards the middle they are on the line and at the extreme right they are under the line, again showing a tendency to be positively skewed. Figure 16 shows that the points cluster approximately in a pattern of upward 'V' indicating a slight positive skewness.

In the Pre-test there is a tendency for scores on Mathematical Creativity to be cumulated at the left indicating a lower level of Mathematical Creativity among upper primary school students. Though the graphs show a slight trend to be positively skewed, the statistical values show that the deviation is not statistically significant.

Comparison of mean scores of post-test on Mathematical Creativity and its components of experimental and control groups

Since quasi-experimental design was followed, experimental and control groups were not equated on their initial characteristics. Hence the mean scores of initial level of Mathematical Creativity and its components (pre-test) of experimental and control groups were compared using two-tailed test of significance of difference between means for large independent groups. The details of the analysis done are given as table 30.

Table 30

Details of Comparison of Mean Pre-test scores on Mathematical Creativity and its Components of Experimental and Control Groups

	Group	**N**	**Mean**	***Sd***	***t*-value**
Mathematical Creativity	Experimental Group	70	65.8	26.92	
	Control Group	70	71.31	26.52	1.22
Fluency	Experimental Group	70	17.14	6.64	
	Control Group	70	15.39	4.74	1.8
Flexibility	Experimental Group	70	14.7	5.42	
	Control Group	70	13.77	4.42	1.11
Originality	Experimental Group	70	22.4	13.67	
	Control Group	70	28.67	15.75	2.52*
Elaboration	Experimental Group	70	11.56	5.47	
	Control Group	70	13.47	4.55	2.26*

Note:- * denotes $p \leq .05$

Results and Discussion

From table 30, it can be seen that the critical ratio for the pre- test mean score on Mathematical Creativity is 1.22 for experimental and control groups. This value is lower than the tabled value (1.96) for significance at .05

level. Hence the difference in the pre- test mean score on Mathematical Creativity of the experimental and control groups is not significant even at .05 level. That is the initial level mean score of Mathematical Creativity (pre-test) of the experimental group (students using the package) and control group (students not using the package) are almost equal.

Table 30 shows that the critical ratio calculated for the pre- test mean score on Fluency is 1.8, which is lower than the tabled value for significance at .05 level. So the pre- test mean scores on Fluency do not differ significantly for experimental and control groups ($p > .05$). That is the pre-test mean score on Fluency of the experimental group and control group are almost equal. Hence experimental and control groups do not differ significantly in their initial level of Fluency.

Table 30 shows that the critical ratio obtained for the pre-test mean score on Flexibility is 1.11, a smaller value than the tabled value for significance at .05 level. It means that the two groups do not differ significantly in the pre- test mean score on Flexibility.

From table 30, it can be seen that the critical ratio calculated for the pre-test mean scores on Originality is 2.52 for experimental and control groups. This value is higher than the tabled value (1.96) for significance at .05 level. Hence it can be inferred that the mean scores on Originality of the experimental and control groups differ significantly ($p \leq .05$). A close observation of mean scores on Originality reveals that higher mean score is for control group. That is control group excel in their Originality mean score than the experimental group.

It can be seen that the critical ratio for the pre-test mean scores on Elaboration 2.26 is higher than the tabled value (1.96) at .05 level of significance. Hence it can be inferred that the mean scores on Elaboration of the control and experimental groups differ significantly ($p \leq .05$). The mean values reveal that higher value is for control group and hence control group has a higher Elaboration mean score compared to the experimental group.

From table 30, it can be concluded that the experimental and control groups are equivalent in terms of mean scores on Mathematical Creativity and two of its components Fluency and Flexibility. The two groups differ in the case of Originality and Elaboration, the difference being in favor of control group in both cases.

Thus experimental and control groups can be considered as equivalent in the mean scores on Mathematical Creativity before the experiment. Though they differ in Originality and Elaboration higher value exist for the control group.

The diagrammatic representation of the comparison of pre-test mean scores of Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration of the experimental group and control group is shown in figure 17.

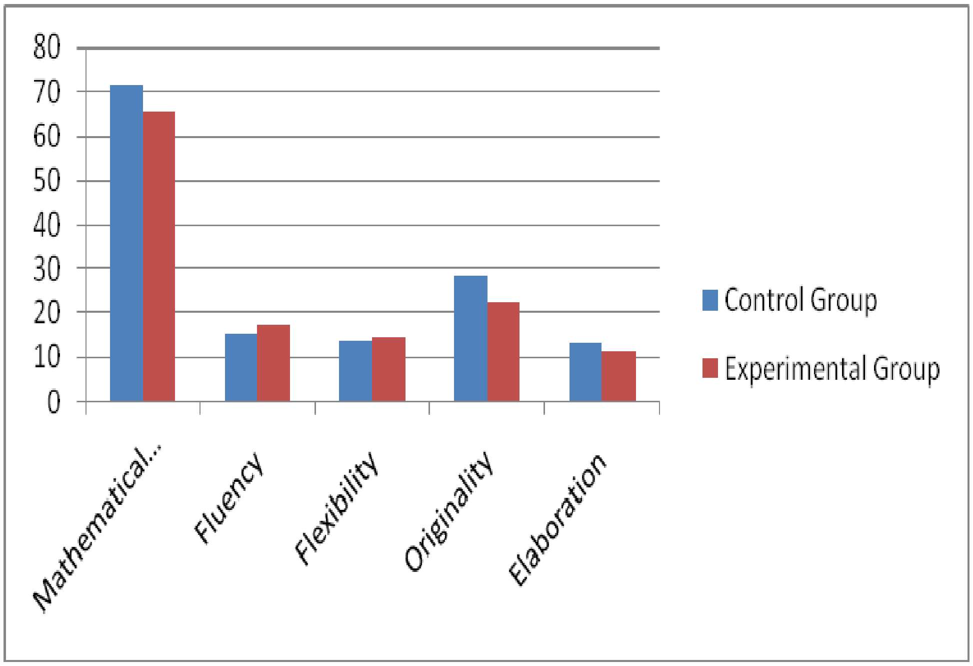


Figure 17: Mean pre-test scores on Mathematical Creativity and its components of experimental and control groups

From the figure it is clear that pre-test Mean Scores of two components of Mathematical Creativity viz., Originality and Elaboration of the experimental group are comparatively lower than that of control group. But the pre-test mean scores of Fluency and Flexibility of the experimental group are comparatively higher than that of control group. However the pre-test mean scores of Mathematical Creativity, which is the sum of mean scores of all the four components of the experimental group is comparatively lower than that of control group.

Comparison of Mean Post-test Scores of Mathematical Creativity and its Components of Experimental and Control Groups

The mean post-test scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration of experimental and control groups were compared using the one-tailed test of significance of difference between means for large independent samples. The mean, standard deviation and critical ratio in each case is given in table 31.

Table 31

Details of Comparison of Mean Post-test Scores on Mathematical Creativity and its Components in Experimental and Control Groups

Variable	Group	N	Mean	*Sd*	*t*-value
Mathematical Creativity	Experimental Group	70	167.9	47.47	
	Control Group	70	86.23	29.24	12.26**
Fluency	Experimental Group	70	32	7.98	
	Control Group	70	17.2	4.74	13.33**
Flexibility	Experimental Group	70	29.44	8.02	
	Control Group	70	14.19	4.71	13.72**
Originality	Experimental Group	70	77.41	26.88	
	Control Group	70	41.01	17.94	9.42**
Elaboration	Experimental Group	70	29.04	8.91	
	Control Group	70	13.83	4.76	12.6**

Note: - ** Denotes $p \leq .01$

Results and Discussion

From table 31, it can be seen that the critical ratio for the post-test mean score on Mathematical Creativity is 12.26 for experimental and control groups. This value is higher than the tabled value (2.33) for significance at .01 level. Hence the post-test mean scores on Mathematical Creativity of the experimental group is higher than that of control group. That is in the post-test, students using the package has a higher score on Mathematical Creativity compared to that of students not using the package.

Table 31 shows that the critical ratio for the post-test mean score on Fluency is 13.38, which is greater than the tabled value for significance at .01 level. Hence the post-test mean scores on Fluency of the experimental group is higher than that of control group. That is, in the post-test, students using the package has a higher score on Fluency compared to that of students not using the package.

Table 31 shows that the critical ratio obtained for post-test mean score on Flexibility 13.33 is greater than the tabled value for significance at .01 level. It means that the post-test mean scores on Flexibility of the experimental group is higher than that of control group. That is, in the post-test, students using the package have a higher mean score on Flexibility compared to that of students not using the package.

From table 31, the calculated critical ratio for post-test mean score on Originality is found to be 9.42. This value is higher than the tabled value for significance at .01 level. It means that the post-test mean scores on Originality of the experimental group is higher than that of control group. That is, in the post-test, students using the package have a higher mean score on Originality compared to that of students not using the package.

Table 31 reveals that the critical ratio for the post-test mean scores on Elaboration is 12.6, a higher value than that required for significance at .01 level ($p \leq .01$). Hence the experimental group has a higher mean post-test score on Elaboration than that of control group. That is students using the package have a higher mean score on Elaboration in the post-test, compared to that of students not using the package.

Bar diagrams for comparison of post-test Mean Scores of Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration of the experimental group and control group is given as figure 18.

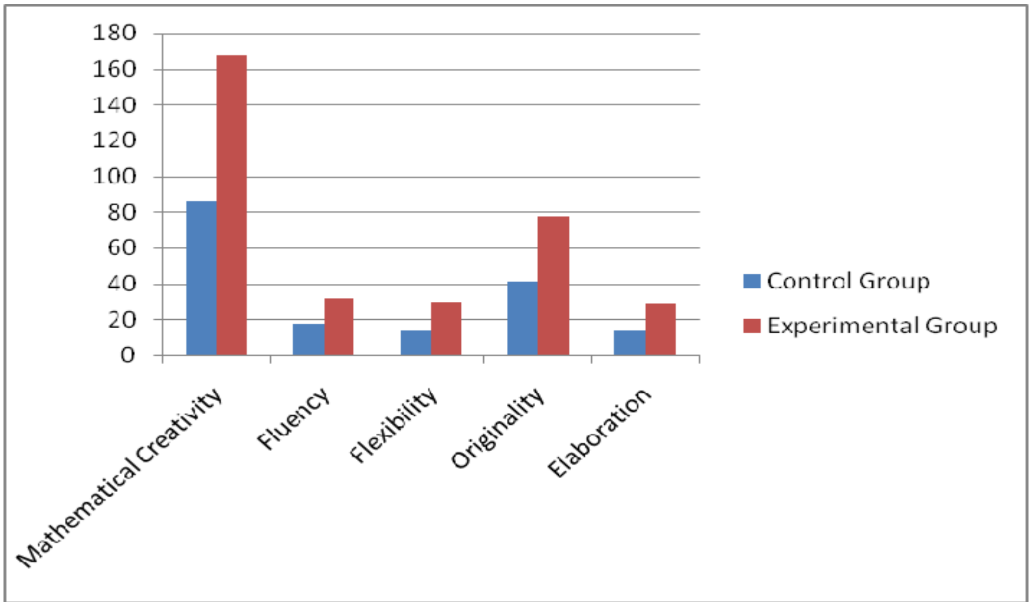


Figure 18: Mean post-test scores on Mathematical Creativity and its components in experimental and control groups

From figure 18, it is vivid that post-test mean scores on Mathematical Creativity and all the four components viz., Fluency, Flexibility, Originality and Elaboration of the experimental group are much higher than that of control group.

Comparison of mean scores of pre-test and post-test on Mathematical Creativity and its components of the experimental group

The mean scores of Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration in both pre- test and post-test for the experimental group was compared using one-tailed test of significance of differences between means for large dependent samples. Table 32 gives the details of analysis.

Table 32

Details of Comparison of Mean Scores of Mathematical Creativity and its Components in Pre-test and Post-test of Experimental Group

Variable	**Test**	**Mean**	***Sd***	***r***	***df***	***t*-value**
Mathematical Creativity	Post-test	167.9	47.47	.64	138	15.66**
	Pre-test	65.8	26.92			
Fluency	Post-test	32	7.98	.58	138	11.97**
	Pre-test	17.14	6.64			
Flexibility	Post-test	29.44	8.02	.59	138	12.74**
	Pre-test	14.7	5.42			
Originality	Post-test	77.41	26.88	.4	138	15.26**
	Pre-test	22.4	13.67			
Elaboration	Post-test	29.04	8.91	.4	138	13.99*
	Pre-test	11.56	5.47			

Note:- ** Denotes $p \leq .01$

Results and Discussion

From table 32, it can be seen that the critical ratio for mean score on Mathematical Creativity in the post- test and pre- test is 15.66 and coefficient of correlation is .64 for the experimental group. The t-value is greater than the tabled value (2.33) at .01 level of significance. Hence it can be inferred that the mean score on Mathematical Creativity in the post-test is significantly higher than that of pre-test for the students using the package.

The critical ratio obtained for mean scores in the case of Fluency is 11.97 and coefficient of correlation is .58 for the experimental group. The t-value is greater than the tabled value at .01 level of significance. It indicates that the mean score on Fluency in the post-test is higher than that of the pre-test for the students using the package.

Table 32 shows that the critical ratio for mean score on Flexibility is 12.74 and coefficient of correlation is .59. The t-value is greater than the tabled value at .01 level of significance. It indicates that the mean score of Flexibility in post- test is higher than that in pre-test among the students using the package.

The critical ratio obtained in the case of mean scores of Originality is 15.26, and the coefficient of correlation is .4. The t-value is greater than the tabled value required for significance at.01 level. It indicates that the mean score of Originality in the post-test is higher than that in pre-test for students using the package.

The calculated critical ratio for mean score on Elaboration is 13.99, and the coefficient of correlation is .4. The t-value is greater than the tabled value at .01 level of significance. It indicates that the mean score of Elaboration in post- test is higher than that in pre-test for the students using the package.

Figure 19 shows the diagrammatic representation of comparison of mean scores of Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration in pre-test and post-test for the experimental group.

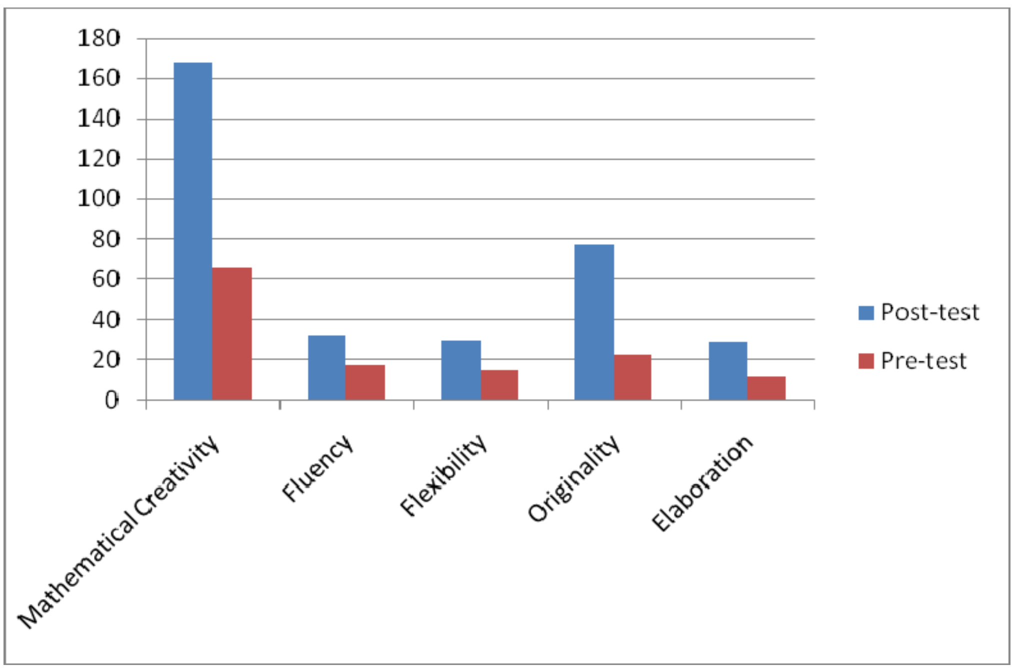


Figure 19: Mean scores of Mathematical Creativity and its components in pre-test and post-test for the experimental group

From figure 19, it is obvious that Mean Scores of Mathematical Creativity and all the four components viz., Fluency, Flexibility, Originality and Elaboration in the post-test are much higher than that in pre-test.

Comparison of mean scores of pre–test and post-test on Mathematical Creativity and its components of the control group

The mean scores of Mathematical Creativity and its components viz., fluency, flexibility, originality and elaboration in both pre- test and post-test for the control group was compared using one-tailed test of significance of difference between means for large dependent samples. Table 33 gives the details of the analysis.

Table 33

Details of Comparison of Mean Scores of Mathematical Creativity and its Components in Pre-test and Post-test of the Control Group

Variable	**Test**	**Mean**	***Sd***	***r***	***df***	***t*-value**
Mathematical Creativity	Post-test	86.23	28.81	0.93	138	3.16**
	Pre-test	71.3	26.52			
Fluency	Post-test	17.27	4.91	0.96	138	2.26*
	Pre-test	15.39	4.74			
Flexibility	Post-test	14.1	4.81	0.83	138	.54
	Pre-test	13.77	4.42			
Originality	Post-test	40.63	17.53	0.87	138	4.33**
	Pre-test	28.67	15.75			
Elaboration	Post-test	14.33	4.72	0.82	138	.46
	Pre-test	13.47	4.49			

Note:- ** Denotes $p \leq .01$ and * denotes $p \leq .05$.

Results and Discussion

From table 33, it can be seen that the critical ratio for the mean score on Mathematical Creativity is 3.16 and coefficient of correlation is .93 for the control group. The t-value is greater than the tabled value (2.33) at .01 level of significance. Hence the mean score on Mathematical Creativity is significantly higher in post-test than pre-test for the students not using the package.

The critical ratio obtained for the mean scores in the case of Fluency is 2.26 and the coefficient of correlation is .96. The t-value is greater than the tabled value at .05 level of significance. Hence the mean score of Fluency is significantly higher in post-test than pre-test for the students not using the package.

Table 33 shows that the critical ratio for the mean score on Flexibility is .54 and the coefficient of correlation is .83. The t-value is lower than the tabled value (1.65) for significance at .05 level. It indicates that the mean score on Flexibility in post- test is not significantly higher than that in pre-test even at .05 level for the control group. Hence for students not using the package, mean score on Flexibility in the post-test is not higher than that in pre-test.

The critical ratio obtained for the mean scores of Originality is 4.33 and the coefficient of correlation is .87. The t-value is greater than the table value for significance at .01 level. Hence the mean score on Originality is significantly higher in post-test than pre-test among the students not using the package.

The calculated critical ratio for mean score on Elaboration is .46 and the coefficient of correlation is .82. The t-value is lower than the tabled value for significance at .05 level. It indicates that the mean score of Elaboration in post- test is not significantly higher than that in pre-test even at .05 level for the control group. Hence for the students not using the package, mean score on Elaboration in post-test is not higher than that in pre-test.

Figure 20 depicts the comparison of mean scores of Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration in pre-test and post-test of the control group.

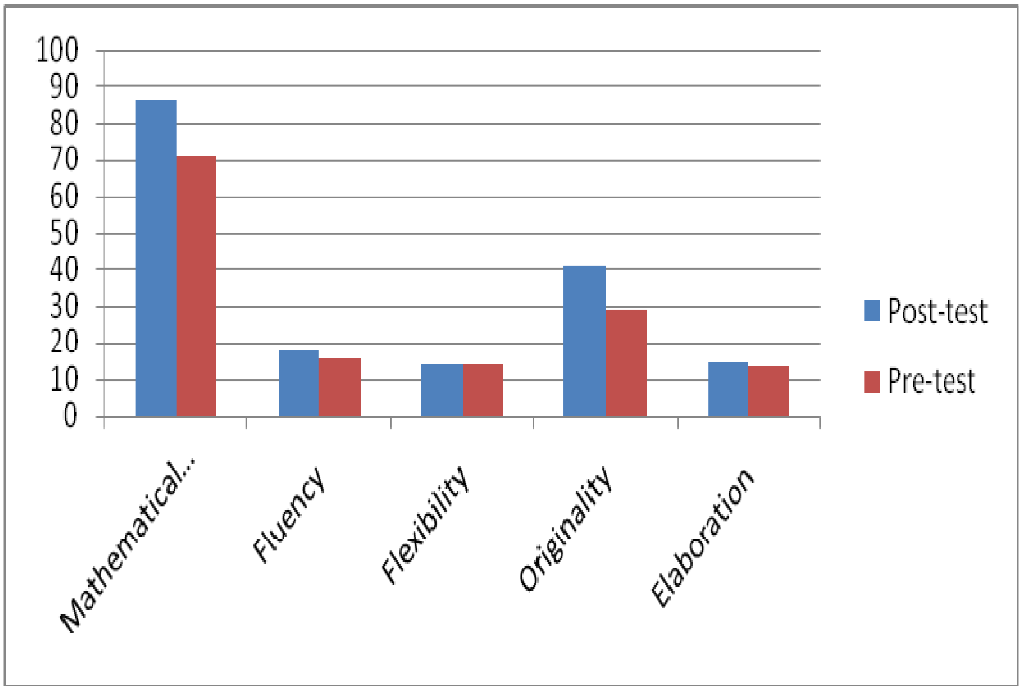


Figure 20: Mean scores of Mathematical Creativity and its components in pre-test and post-test of the control group

From figure 20, it is obvious that mean scores on Mathematical Creativity and one of its components Originality are significantly higher in post-test than in pre-test for the control group. For Fluency, the bar corresponding to post-test is just higher than that of pre-test. For Flexibility and Elaboration, the bars corresponding to pre-test and post-test are almost equal.

To get a bird's eye view of the initial and final levels of Mathematical Creativity and its components Fluency, Flexibility, Originality and Elaboration among experimental and control groups, line graphs are drawn and are presented as figure 21 to figure 40.

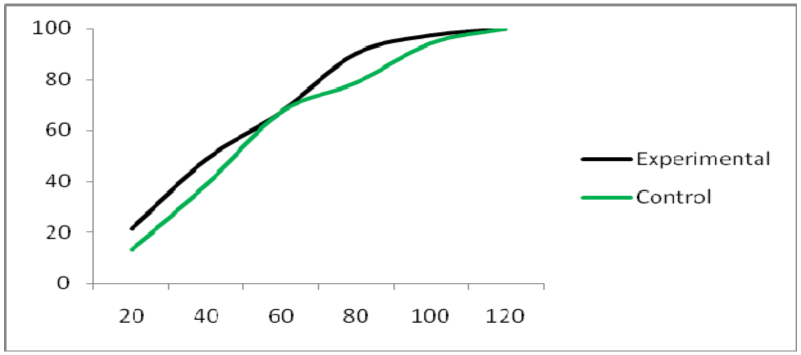


Figure 21. Ogives on pre-test Mathematical Creativity scores of experimental and control groups

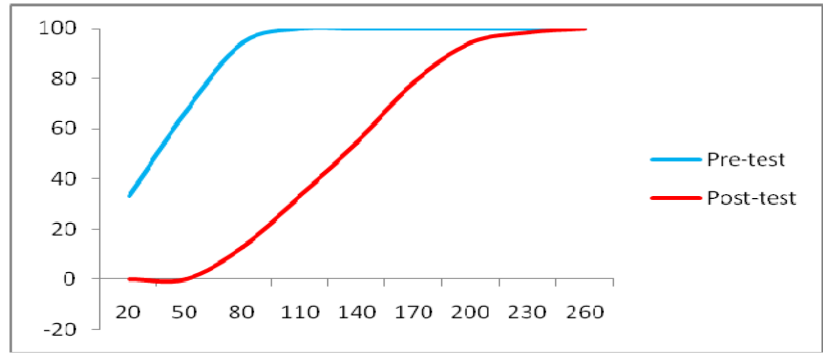


Figure 23 Ogives on Mathematical Creativity of the experimental group in pre-test and post-test scores

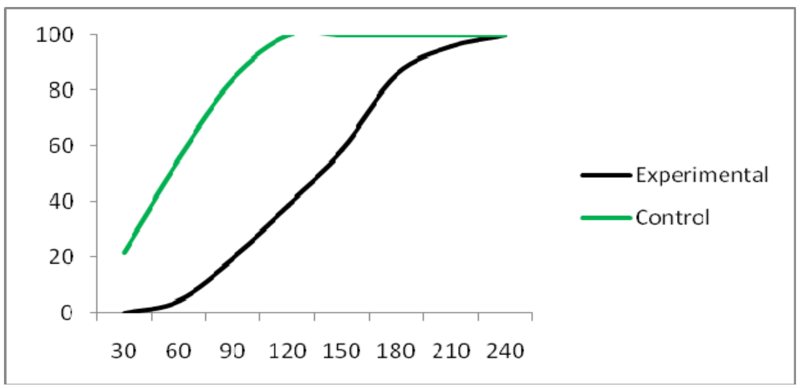


Figure 22. Ogives on post-test Mathematical Creativity scores of experimental and control groups

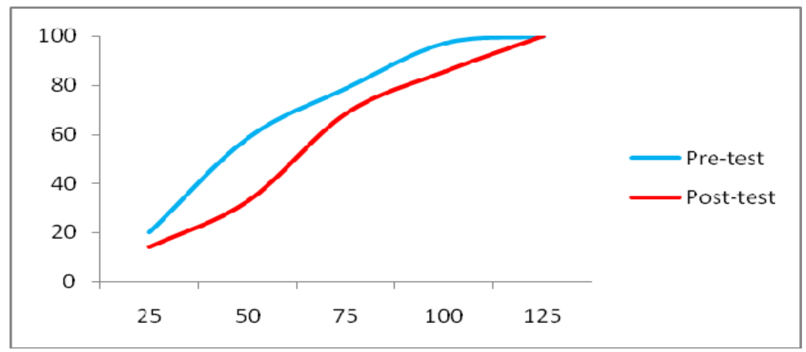


Figure 24. Ogives on Mathematical Creativity of the control group in pre-test and post-test scores

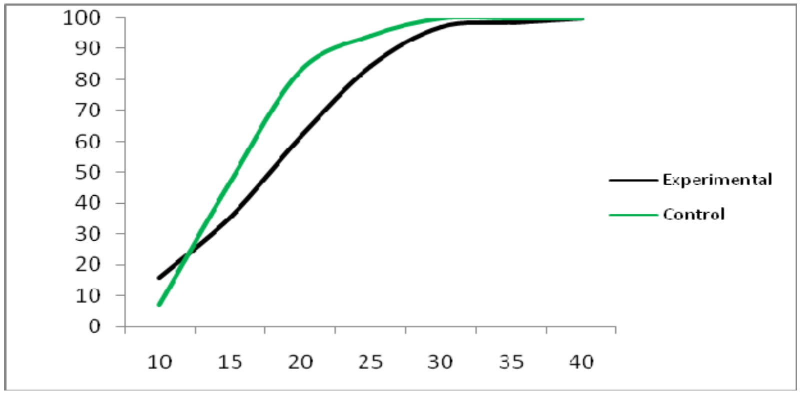


Figure 25. Ogives on pre-test Fluency scores of experimental and control groups

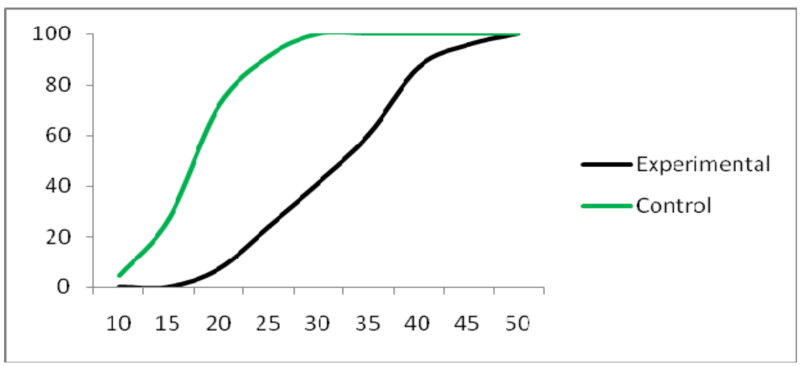


Figure 26. Ogives on post-test Fluency scores of experimental and control groups

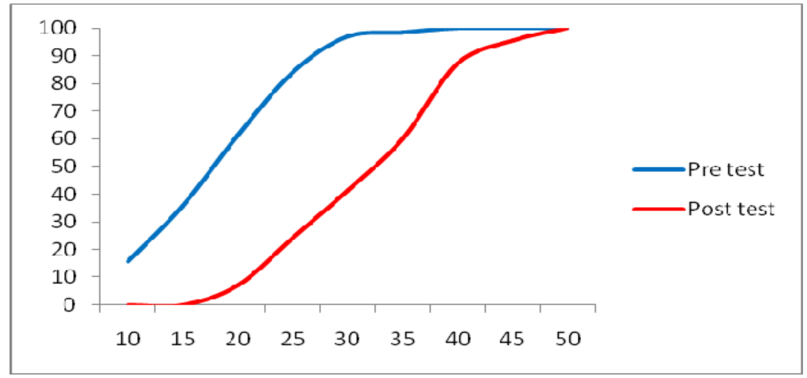


Figure 27. Ogives on Fluency scores of the experimental group in pre-test and post-test

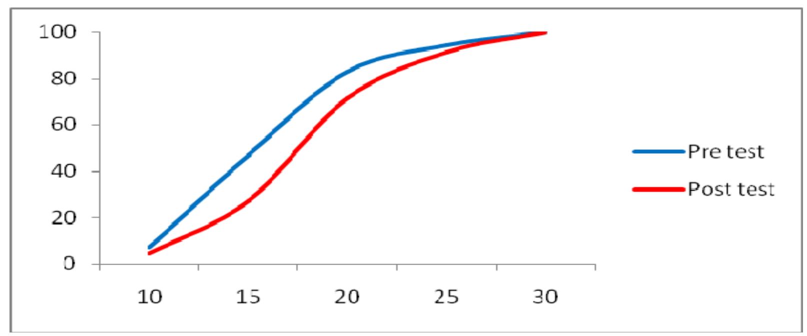


Figure 28. Ogives on Fluency of the control group in pre-test and post-test scores

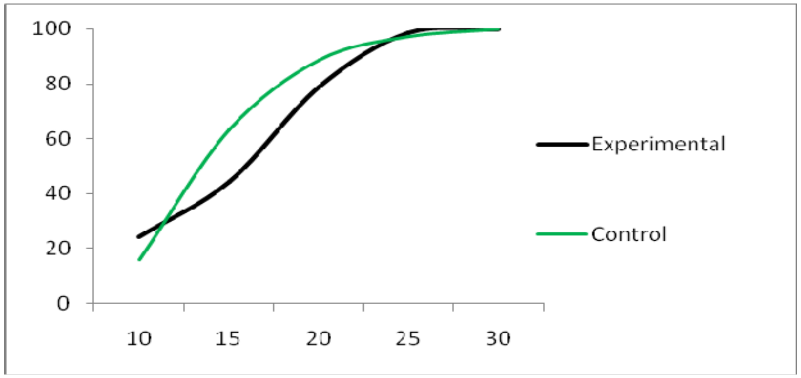


Figure 29. Ogives on pre-test Flexibility scores of experimental and control groups

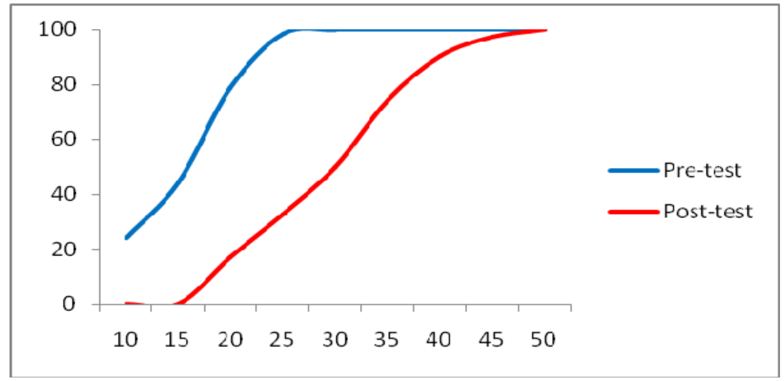


Figure 30. Ogives on post-test Flexibility scores of experimental and control groups

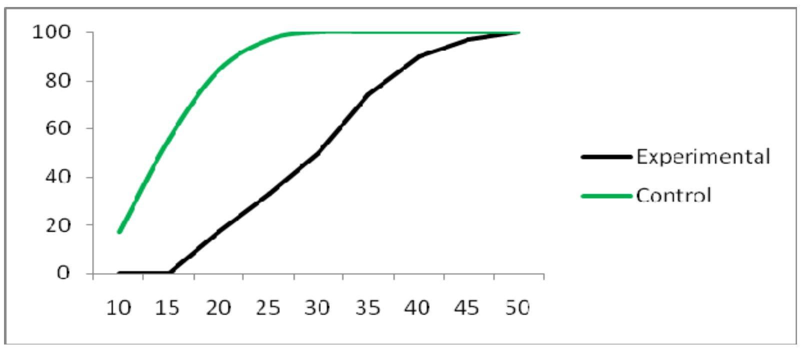


Figure 31. Ogives on Flexibility of the experimental group in pre-test and post-test scores

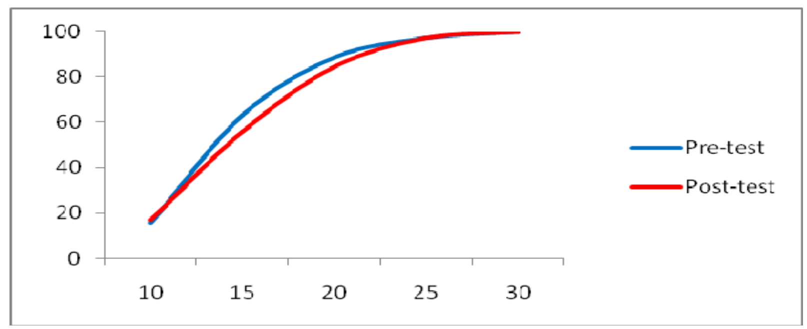


Figure 32. Ogives on Flexibility of the control group in pre-test and post-test scores

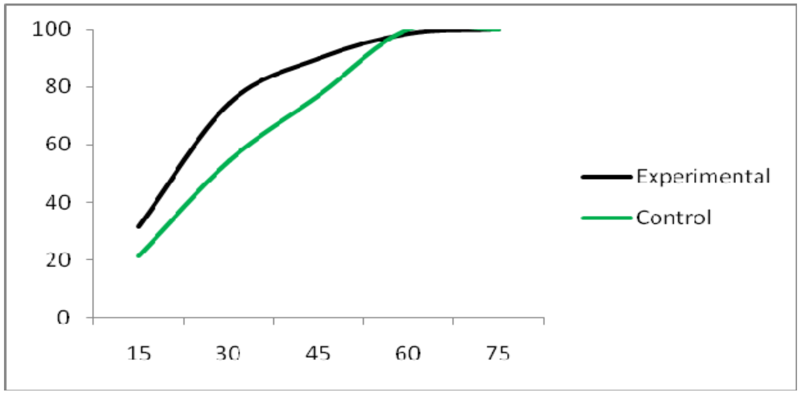


Figure 33. Ogives on pre-test Originality scores of experimental and control groups

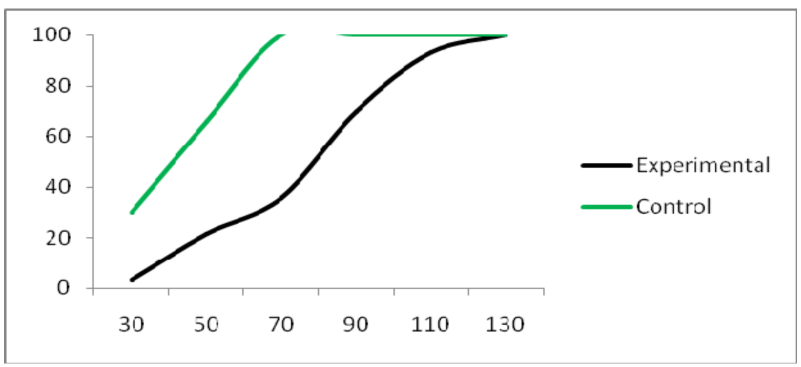


Figure 34. Ogives on post-test Originality scores of experimental and control groups

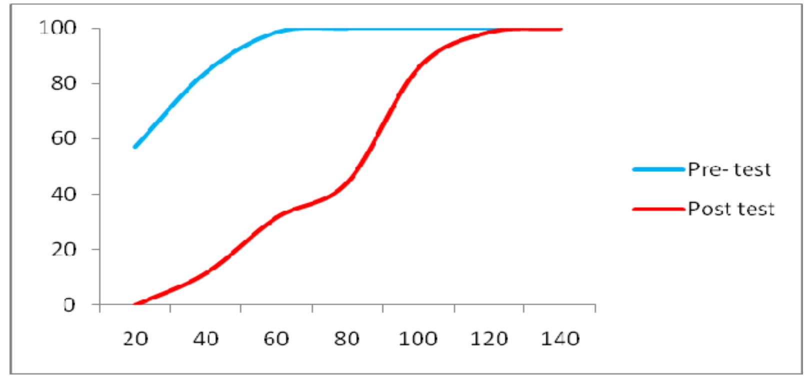


Figure 35. Ogives on Originality of the experimental group in pre-test and post-test scores

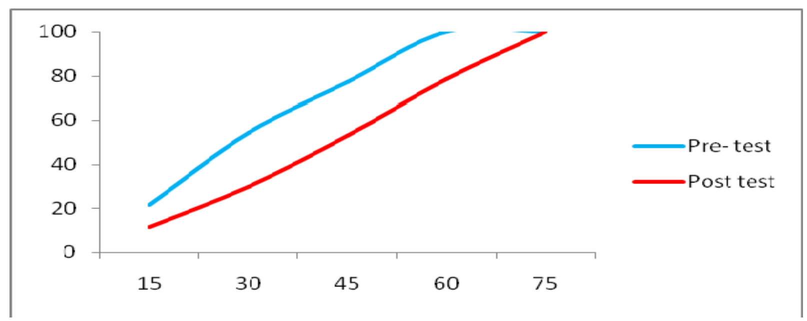


Figure 36. Ogives on Originality of the control group in pre-test and post-test scores

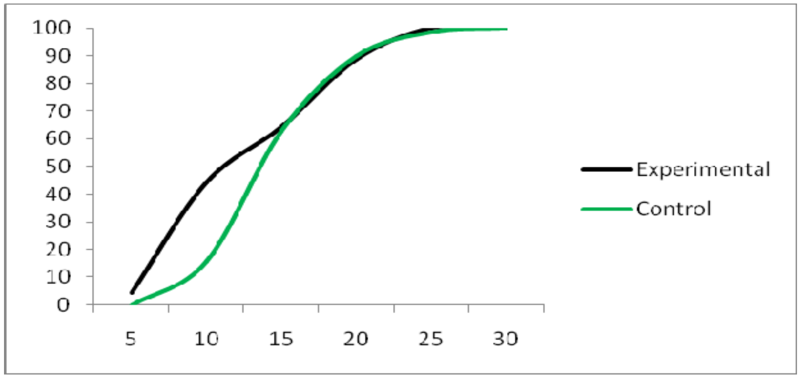


Figure 37. Ogives on pre-test Elaboration scores of experimental and control groups

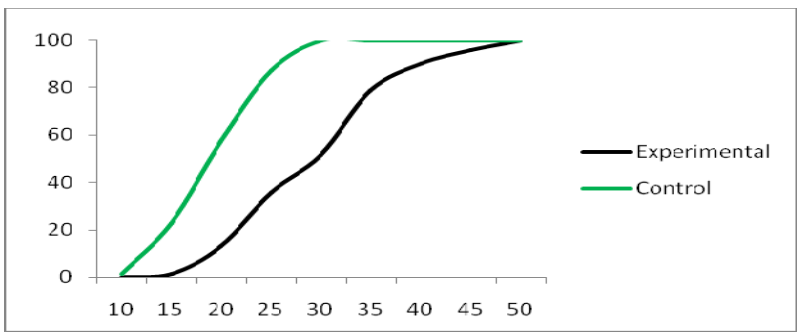


Figure 38. Ogives on post-test Elaboration scores of experimental and control groups

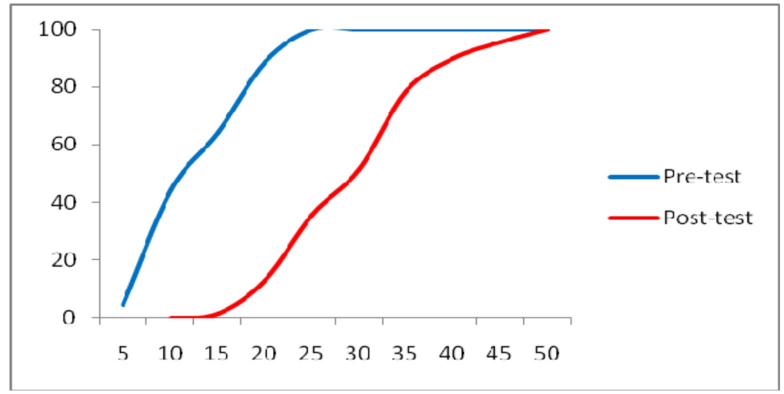


Figure 39. Ogives on Elaboration of the experimental group in pre-test and post-test scores

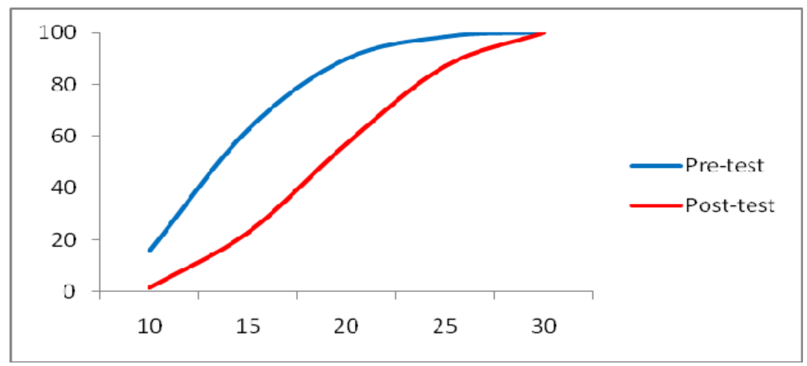


Figure 40. Ogives on Elaboration of the control group in pre-test and post-test scores

Figure 21 gives a clear idea of the level of Mathematical Creativity among experimental and control groups at the initial level where as figure 22 does that at the end of the experiment. Figure 23 shows the difference in the level of Mathematical Creativity before and after the experiment among the experimental group and figure 24 does the same among control group.

Figure 25 gives a clear idea of the level of Fluency among experimental and control groups at the initial level whereas figure 26 does that at the end of the experiment. Figure 27 shows the difference in the level of Fluency before and after the experiment among the experimental group and figure 28 does the same among control group.

Figure 29 gives a clear idea of the level of Flexibility among experimental and control groups at the initial level where as figure 30 does that at the end of the experiment. Figure 31 shows the difference in the level of Flexibility before and after the experiment among the experimental group and figure 32 does the same among control group.

Figure 33 gives an idea of the level of Originality among experimental and control groups at the initial level and figure 34 does that at the end of the experiment. Figure 35 shows the difference in the level of Originality before and after the experiment among the experimental group and figure 36 does the same among control group.

Figure 37 gives a clear idea of the level of Elaboration among experimental and control groups at the initial level where as figure 38 does that at the end of the experiment. Figure 39 shows the difference in the level of Elaboration before and after the experiment among the experimental group and figure 40 does the same among control group.

Comparison of mean gain scores on Mathematical Creativity and its components of experimental and control groups

The mean gain scores of Mathematical Creativity and its components viz., fluency, flexibility, originality and elaboration of both experimental and control groups were compared using one-tailed test of significance of difference between means for large independent samples. Table 34 gives the details of the analysis.

Table 34

Details of Comparison of Mean Gain Scores of Mathematical Creativity and its Components between Experimental and Control Groups

Variable	**Group**	**Mean**	***Sd***	***t*-value**
Mathematical Creativity	Experimental Group	102.1	36.78	19**
	Control Group	14.93	11.02	
Fluency	Experimental Group	14.86	6.84	15.67**
	Control Group	1.81	1.32	
Flexibility	Experimental Group	14.74	6.5	17.06**
	Control Group	.41	2.67	
Originality	Experimental Group	55.01	24.88	13.54**
	Control Group	12.34	8.72	
Elaboration	Experimental Group	17.49	8.36	16.24**
	Control Group	.36	2.81	

Note:- ** Denotes $p \leq .01$

Results and Discussion

From Table 34, it can be seen that the critical ratio for the mean gain score on Mathematical Creativity between experimental and control groups is 19. This value is higher than the tabled value (2.33) for significance at .01 level. Hence it can be inferred that the mean gain score on Mathematical Creativity is higher for students using the package than that of students not using the package.

Table 34 shows that the calculated value of critical ratio for the mean gain score on Fluency is 15.67, which is greater than the tabled value for significance at .01 level. That is, experimental group has a significantly higher mean gain score on Fluency than the control group. Hence it can be concluded that the mean gain score on Fluency is higher for students using the package than that of students not using the package.

Table 34 shows that the critical ratio obtained for mean gain score on Flexibility is 17.06 which is greater than the tabled value for significance at .01 level. That is, the mean gain score on Flexibility is higher for experimental group than the control group. It means that the mean gain score on Flexibility is higher for students using the package than that of students not using the package.

From table 34, the calculated critical ratio for mean gain score on Originality is found to be 13.54. This value is higher than the tabled value for significance at .01 level. That is, the experimental group has a significantly higher mean gain score in Originality than the control group. Hence the mean gain score on Originality for students using the package is higher than that of students not using the package.

Table 34 reveals that the critical ratio for the mean gain scores on Elaboration is 16.24, a higher value than that required for significance at 0.01 level ($p \leq .01$). That is, the experimental group has significantly higher mean gain score in Elaboration compared to control group. Hence the mean gain score on Elaboration for students using the package is higher than that of students not using the package.

Bar diagrams are drawn for easy comparison of mean gain scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration of the experimental group and control group and is given as figure 41.

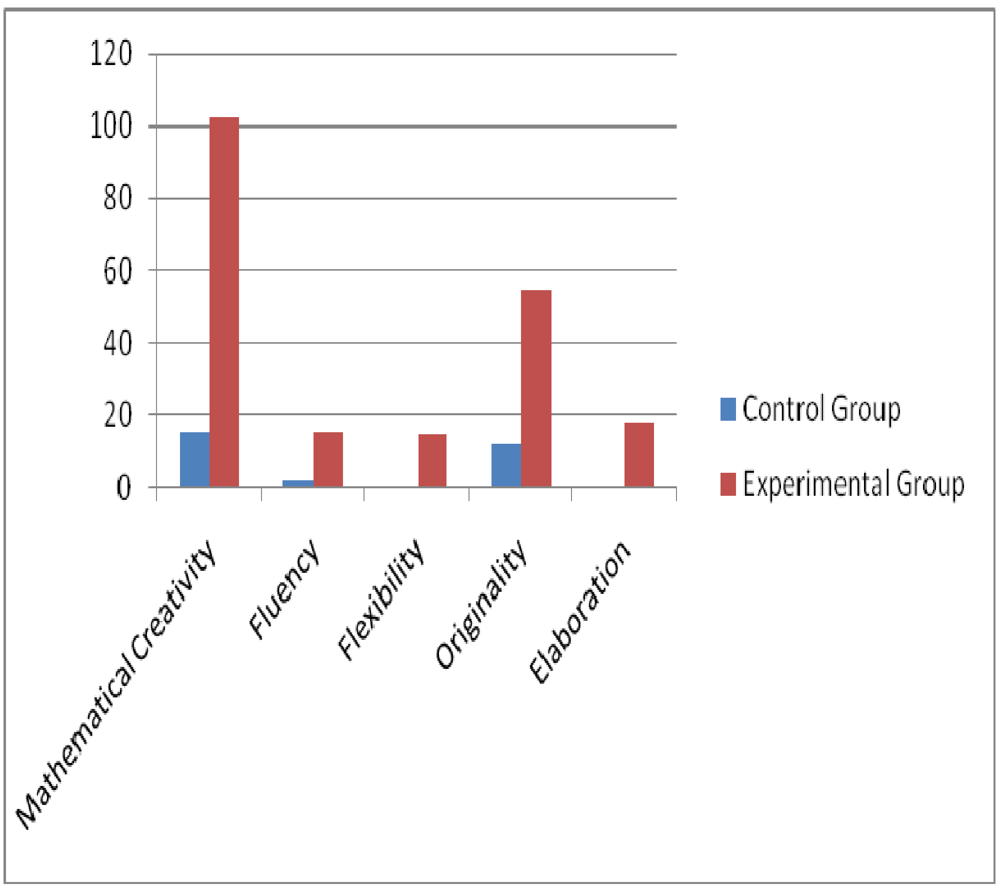


Figure 41: Mean gain scores on Mathematical Creativity and its components of experimental and control groups

From figure 41, it is vivid that mean gain scores on Mathematical Creativity and all the four components selected in the study viz., Fluency, Flexibility, Originality and Elaboration of the experimental group are much higher than that of control group.

Comparison of mean gain scores on Mathematical Creativity of Experimental and control groups with Intelligence and pre-test score on Mathematical Creativity as covariates

ANCOVA helps the investigator assess the effect of the independent variable on the dependent variable more accurately by explaining the unexplained variance in terms of covariates.

Hence the influence of Intelligence and initial level of Mathematical Creativity (pre-test score on Mathematical Creativity) on the attained Mathematical Creativity through the experiment were removed by executing ANCOVA with Intelligence measured through CPM and initial level of Mathematical Creativity as covariates. The details are given as table 35 and table 36.

Table 35

Summary of ANOVA of Gain Score on Mathematical Creativity by Groups

Source	**Sum of squares**	***df***	**Mean square**	***F***
Corrected model	236489.4	1	236489.4	485.93
Intercept	439488.11	1	439488.11	903.05
Group	236489.4	1	236489.4	485.93
Error	67160.49	138	486.67	
Total	743138	140		
Corrected total	303649.89	139		

Results and Discussion

Table 35 shows that the total variance explained by the model is 303649.89 when Intelligence and initial level of Mathematical Creativity were not included. The variance explained by the experimental manipulation is 236489.4. The F value obtained is 485.93 which is greater than the tabled value of F (1,139) for significance at .01 level (6.82) and hence the experiment has significant effect on the gain score on Mathematical Creativity. That is the module has brought change in the gain Mathematical Creativity score of upper primary school students.

Table 36

Summary of ANCOVA of Gain Scores on Mathematical Creativity by Groups with Intelligence and Initial Level of Mathematical Creativity as Covariates

Source	**Sum of Squares**	***df***	**Mean Square**	***F***
Corrected Model	251970.54	3	83990.18	221.03
Intercept	1923.98	1	1923.98	5.06
Intelligence	13700.58	1	13700.58	36.06
Pre-test score	1171.75	1	1171.75	3.08
Group	243520.34	1	243520.34	640.85
Error	51679.35	136	380	
Total	743138	140		
Corrected Total	303649.88	139		

Results and Discussion

Table 36 shows that Intelligence is a significant predictor of the dependent variable ($F=36.06$, $p<0.01$) but initial level of Mathematical Creativity is not a significant predictor of the gain score on Mathematical Creativity ($F=3.08$). When these two variables are included as covariates, the total sum of squares remained the same as 303649.89 units, but the variance explained by the experiment has increased to 243520.34 units whilst it was 236489.4 units when these variables were not controlled. That is, when the influence of Intelligence and pre-test score on Mathematical Creativity was removed, the variance explained by the experiment is 243520.34 units. The unexplained variance has been reduced to 51679.35 from 67160.49. Hence the experiment has significant effect on gain score on Mathematical Creativity.

Comparison of mean scores of pre-test and successive tests on Mathematical Creativity of the experimental group.

One way repeated measures ANOVA was used to compare the mean scores of pre-test and the formative tests. The formative tests were taken as the score per item of the total of tests of four modules each. For this sum of scores obtained for Mathematical Creativity in the first four tests was calculated and was divided with number of items (12). Similarly last four test scores were added and were divided by 12. The pre-test scores were also divided by number of items (6). These scores were taken as the pre-test score, formative 1 score and formative 2 score. The condition of sphericity was tested and one way repeated measures ANOVA was executed. The descriptive statistics and the details of test of sphericity are given as table 37 and table 38.

Table 37

Descriptive Statistics of the Three Levels of Scores viz., Pre-test, Formative 1 and

Formative 2 (N=70)

Tests	**Mean**	***Sd***
Pre-test	10.97	4.49
Formative Test 1	34.93	10.34
Formative Test 2	48.85	12.42

Results and Discussion

The mean score on pre-test on Mathematical Creativity (per item score) is 10.97 with standard deviation4.49 where as it has increased to 34.93 with standard deviation 10.34 in formative test 1 and 48.85 in the standard deviation 12.42 in formative test 2.

Table 38

Details of Test of Sphericity of Data

Within Subject Effect	**Mathematical Creativity**
Mauchly's w	.512
Chi-square	45.587
Degrees of freedom	2
Green-House-Geisser	.672
Huynh-Feldt	.68
Lower bound	.5

Results and Discussion

Table 38 shows that the Mauchly's w is .512 with χ^2- value 45.587 (df = 2). Significance at 0.01 level warrants deviation from sphericity. The values of Green House- Geisser and Huynh-Feldt are more close to the lower bound than the upper bound, again indicating violation of the assumption of sphericity.

Since Mauchly's test indicated that the assumption of sphericity had been violated, degrees of freedom were corrected using Green house – Geisser estimation of sphericity. Though assumption of sphericity was violated, using the correction of degrees of freedom, further analysis was done. The details of ANOVA are given as table 39.

Table 39

Details of Tests of within Subjects Effects

Statistic	**Source**	**Sum of squares**	***df***	***MS***	***F*-value**
Sphericity assumed	Mathematical Creativity	51393.09	2	25696.54	807.37**
	Error	4392.21	138	31.83	
Green house Geisser	Mathematical Creativity	51393.09	1.34	38249.19	807.37**
	Error	4392.21	92.71	47.38	
Huynh-Feldt	Mathematical Creativity	51393.09	1.36	37771.77	807.37**
	Error	4392.21	93.88	46.78	
Lower bound	Mathematical Creativity	51393.09	1	51393.09	807.37**
	Error	4392.21	69	63.66	

Results and Discussion

Assuming sphericity by correcting the degrees of freedom the F values obtained in all the three cases are the same (807.367) but with different degrees of freedom. These values are greater than the tabled value of F for the respective degrees of freedom, and hence there is significant difference in the mean scores of the three levels of scores on Mathematical Creativity. That is, the mean scores on pre-test, formative 1 and formative 2 of the participants using the package differ significantly.

The variance in the mean scores explained by the experiment is 51393.09 and unexplained is 4392.21.

Results of ANOVA showed that the differences in the mean scores on pre-test, formative 1 and formative 2 of Mathematical Creativity of the participants using the package are significant ($p \leq .01$). To test whether the effect is substantive, regardless of significance, effect size was calculated, using multi-variate tests, the details of which are given as table 40.

Table 40

Details of Effect Size using Multi Variate Tests

	Value	**F**	***df.***	**Sig.**	**Partial Eta Squared**
Pillai's trace	.935	489.2	2	.01	.935
Wilks' lambda	.065	489.2	2	.01	.935
Hotelling's trace	14.389	489.2	2	.01	.935
Roy's largest root	14.389	489.2	2	.01	.935

Results and Discussion

Table 40 shows that the effect size of the experiment on Mathematical Creativity calculated though different methods are significant at .01 level. Also the partial Eta squared value in each case is .935, a higher value than .14, the value for large effect. Since the mean difference is significant, post-hoc comparison was made and the details are given as table 41.

Table 41

Comparison of Mean Scores on Pre-test, Formative 1 and Formative 2 of Mathematical Creativity

Source	**Mathematical Creativity**	**Sum of Squares**	***df***	***MS***	***F*-value**	**Level of Significance**	**Partial Eta Squared**
Mathematical Creativity	Level 1 vs Level 2	40180.12	1	40180.12	641.82	.01	.9
	Level 2 vs Level 3	13564.11	1	13564.11	528.57	.01	.89
Error	Level 1 vs Level 2	4319.65	69	62.6	-	-	-
	Level 2 vs Level 3	1770.69	69	25.66	-	-	-

Note:- ** Denotes p ≤ 0.01

Results and Discussion

Table 41 shows that when level 1 and level 2 are compared, that is the pre-test score and formative 1 score are compared, the F value obtained is 641.82 which indicates a significant difference between the two measures($p \leq .01$). That is the pre-test mean score and formative 1 mean score on Mathematical Creativity differ significantly ($p \leq .01$) indicating that the first four modules significantly changed the pre-test score on Mathematical Creativity.

Similarly when level 2 and level 3 are compared (table 41), that is formative 1 score and formative 2 score are compared the F value obtained is 528.57 which indicates a significant difference between the two measures ($p \leq .01$). That is formative 1 mean score and formative 2 mean score on Mathematical Creativity differ significantly ($p \leq .01$) indicating that the last four modules significantly changed the mean score on Mathematical Creativity.

Hence the Package on Geometry is effective to improve Mathematical Creativity of upper primary school students.

Partial eta square in the case of pre-test and formative 1 score is .9 which shows a very large effect of the treatment on the dependent variable.

That is, the first four modules have significantly large effect on Mathematical Creativity of the participants.

In the case of formative I and formative 2 test scores, partial eta square is .89, again showing a very large effect of the treatment on Mathematical Creativity. The last four modules have significantly improved Mathematical Creativity of the participants compared to the formative 1 test score.

Effect size of the treatment on scores of Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration.

The effect size of the 'Package on Geometry' on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration of the experimental group was calculated. The details are given as table 42.

Table 42

Data and Result on the Effect Size of the 'Package on Geometry' on Mathematical Creativity and its Components of the Experimental Group

Variable		**Mean**	***Sd***	**Cohen's *d***	**Glass's Δ**	***r*-value**
Mathematical Creativity	Post-test	174.8	48.61	-	3.79	.79
	Pre-test	65.8	26.92			
Fluency	Post-test	32.78	1.13	2.02	-	.71
	Pre-test	17.14	.79			
Flexibility	Post-test	30.43	1.11	2.15	-	.73
	Pre-test	14.7	.65			
Originality	Post-test	81.8	4.06	-	3.99	.8
	Pre-test	22.4	1.63			
Elaboration	Post-test	29.8	1.3	2.36	-	.76
	Pre-test	11.56	.65			

Results and Discussion

For the experimental group, the Glass's Δ obtained is 3.79 with an effect size .79 ($r \geq .7$) indicates a very large effect of the Package on Geometry on Mathematical Creativity.

The Cohen's d obtained on the mean scores of Fluency is 2.02 with effect size .71 which is greater than the value needed for very large effect($r \geq .7$). Hence the Package on Geometry has very large effect in fostering Fluency among the experimental group.

The Cohen's d obtained on the mean scores of Flexibility is 2.15 with effect size .73 which is greater than the value needed for very large effect ($r \geq .7$). Hence the Package on Geometry has very large effect in fostering Flexibility among the experimental group.

The Glass's Δ obtained is 3.99 on the mean scores of Originality with an effect size .8 which is greater than the value needed for very large effect ($r \geq .7$) indicates a very large effect of the Package on Geometry on Originality.

The Cohen's d obtained on the mean scores of Elaboration is 2.36 with effect size .76 which is greater than the value needed for very large effect ($r \geq .7$). Hence the Package on Geometry has very large effect in fostering Elaboration among the experimental group.

The effect size of the 'Package on Geometry' on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration in post-test of both experimental and control group was calculated. The details are given as table 43.

Table 43

The r-value for experimental and control groups on post-test mean scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration

Variable		**Mean**	***sd***	***N***	**Glass's Δ**	***r*-value**
Mathematical Creativity	Experimental group	167.9	47.47	70	2.79	.72
	Control group	86.23	29.24	70		
Fluency	Experimental group	32	7.98	70	3.12	.75
	Control group	17.2	.74	70		
Flexibility	Experimental group	29.44	8.02	70	3.24	.76
	Control group	14.19	.71	70		
Originality	Experimental group	77.41	26.53	70	1.84	.6
	Control group	41.01	17.94	70		
Elaboration	Experimental group	29.04	8.91	70	3.2	.73
	Control group	13.83	4.76	70		

Results and Discussion

The Glass's Δ obtained on the mean post-test scores of Mathematical Creativity between experimental and control groups is 2.79 with an effect size .72 which is greater than the value needed for very large effect ($r \geq .7$) indicates a very large effect of the Package on Geometry on Mathematical Creativity.

The Glass's Δ obtained on the mean post-test scores of Fluency between experimental and control groups is 3.12 with an effect size .75 which is greater than the value needed for very large effect ($r \geq .7$) indicates a very large effect of the Package on Geometry on Fluency.

The Glass's Δ obtained on the mean post-test scores of Flexibility between experimental and control groups is 3.24 with an effect size .76 which is greater than the value needed for very large effect ($r \geq .7$) indicates a very large effect of the Package on Geometry on Flexibility.

The Glass's Δ obtained on the mean post-test scores of Originality between experimental and control groups is 1.84 with an effect size .6 which is greater than the value needed for large effect ($r \geq .5$) indicates a large effect of the Package on Geometry on Originality.

The Glass's Δ obtained on the mean post-test scores of Elaboration between experimental and control groups is 3.2 with an effect size .73 ($r \geq .7$)

which indicates a very large effect of the Package on Geometry on Elaboration.

Conclusion

Before implementation of the Package on Geometry, the experimental and control groups were found to be same with respect to Mathematical Creativity and its components Fluency and Flexibility. The control group is found to be higher in their mean scores on Originality and Elaboration than the experimental group. After the experiment, the experimental group excelled in their Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration compared to that of control group. Comparison in terms of pre-test and post-test mean scores for the experimental group showed that post-test scores on Mathematical Creativity and its components are significantly higher than that of pre-test, indicating a positive influence of the Package on Geometry on Mathematical Creativity. For the control group also significant improvement in the mean scores of Mathematical Creativity and its components Fluency and Originality were found, the difference being small compared to that of experimental group. But no significant mean difference in pre-test and post -test was observed in the case of Flexibility and Elaboration which are very important aspects of creativity.

When Intelligence and initial scores on Mathematical Creativity were statistically controlled, the effect of the Package on Geometry on Mathematical Creativity was found to be significant by explaining more variance. Also, when mean scores on successive tests on Mathematical Creativity were compared using ANOVA with repeated measures; mean scores on Mathematical Creativity showed an increasing trend during the experimentation. The effect size were calculated using Cohens'd and Glass's Δ and it was found that the Package on Geometry has very large effect in fostering Mathematical Creativity and its components.

JINU M. K. “DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS”. THESIS. RESEARCH CENTRE IN EDUCATION, FAROOK TRAINING COLLEGE, UNIVERSITY OF CALICUT, 2018.

Chapter V

SUMMARY, CONCLUSIONS AND SUGGESTIONS

- ***Study in Retrospect***
- ***Variables***
- ***Objectives of the Study***
- ***Hypotheses of the Study***
- ***Methodology***
- ***Statistical Techniques***
- ***Major Findings of the Study***
- ***Tenability of Hypotheses***
- ***Conclusions***
- ***Educational Implications***
- ***Suggestions for Further Research***

SUMMARY, CONCLUSION AND SUGGESTIONS

This chapter provides a summary of the present study such as the statement, design, variables involved, objectives, hypotheses, methodology, statistical techniques adopted, findings of the study, conclusion arrived at, educational implications and suggestions for further research.

Study in Retrospect

In the present study the investigator constructed and validated the 'Package on Geometry' with a view to foster Mathematical Creativity of upper primary school students. The study was entitled as "DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY SCHOOL STUDENTS".

Variables

The treatment variable has two levels: use of Package on Geometry together with the usual class room experiences and the other usual class room experiences without any exposure to the Package on Geometry.

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 students in the test of Mathematical Creativity developed by the investigator.

Two covariates considered are Intelligence as measured by Colored Progressive Matrices and pre-test score on Mathematical Creativity in order to get a clear picture of the effects of the 'Package on Geometry' to foster Mathematical Creativity among upper primary school students.

Objectives of the Study

The objectives of the present study are

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 to foster Mathematical Creativity among upper primary school students.

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 the 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

Design of the Study

The study followed 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.

Pre-test scores on Mathematical Creativity and Intelligence scores obtained in Raven's CPM were used to control the ceiling effect. Internal validity was ensured by selecting both schools from Government sector, same type of locality (rural) and same performance standard. After each module, successive tests on Mathematical Creativity were administered to the experimental group.

Participants

Seventy upper primary school students (sixth and seventh standard) from CMGHSS, Kuttoor were selected 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 were selected as the control group.

Instruments

The major instruments used in the present study are listed below.

- Raven's Coloured Progressive Matrices (CPM)
- Tests of Mathematical Creativity (Jinu & Vijayakumari, 2014)
- Rating scale on different aspects of the package
- Package on Geometry (Jinu & Vijayakumari, 2014)

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 means for 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

Major Findings of the Study

Analysis was done to find out the effectiveness of 'Package on Geometry' in fostering Mathematical Creativity of upper primary school students.

Following are the major findings of the study.

1. The pre-test mean scores on Mathematical Creativity of experimental and control groups do not differ significantly ($t=1.22$, $p > .05$).

2. The pre-test mean score on Fluency of experimental and control groups do not differ significantly ($t=1.8$, $p > .05$).

3. The pre-test mean score on Flexibility of experimental and control groups do not differ significantly ($t=1.11$, $p > .05$).

4. The pre-test mean score on Originality of experimental and control groups differ significantly, the higher score for control group ($t=2.52$, $p \leq .05$).

5. The pre-test mean score on Elaboration of experimental and control groups differ significantly, the higher score for control group ($t=2.26$, $p \leq .05$).

6. The post-test mean score on Mathematical Creativity is significantly higher for the experimental group than the control group ($t=12.26$, $p \leq .01$).

7. The post-test mean score on Fluency is significantly higher for the experimental group than the control group ($t=13.33$, $p \leq .01$).

8. The post-test mean score on Flexibility is significantly higher for experimental group than the control group ($t=13.72$, $p \leq .01$).

9. The post-test mean score on Originality is significantly higher for experimental group than the control group ($t=9.42$, $p \leq .01$).

10. The post-test mean score on Elaboration is significantly higher for experimental group than the control group ($t=12.6$, $p \leq .01$).

11. The mean score on Mathematical Creativity is significantly higher in the post-test than the pre-test in the experimental group ($t=15.66$, $r=.64$, $p \leq .01$).

12. The mean score on Fluency is significantly higher in the post-test than the pre-test in the experimental group ($t=11.97$, $r=.58$, $p \leq .01$).

13. The mean score on Flexibility is significantly higher in the post-test than the pre-test in the experimental group ($t=12.74$, $r=.59$, $p \leq .01$)

14. The mean score on Originality is significantly higher in the post-test than the pre-test in the experimental group ($t=15.26$, $r=.4$, $p \leq .01$).

15. The mean score on Elaboration is significantly higher in the post-test than the pre-test in the experimental group ($t=13.99$, $r=.4$, $p \leq .01$).

16. The post-test mean scores on Mathematical Creativity of the control group is significantly higher than that of pre-test ($t=3.16$, $r= .93$, $p \leq .01$).

17. The post-test mean scores on Fluency is significantly higher than that of the pre-test for the control group ($t=2.26$, $r = .96$, $p \leq .05$).

18. The post-test mean score on Flexibility is not significantly higher than that in the pre-test for the control group ($t=.54$, $r = .83$, $p > .05$).

19. The post-test mean scores on Originality is significantly higher than that of pre-test for the control group ($t=4.33$, $r = .87$, $p \leq .01$).

20. The post-test mean score on Elaboration is not significantly higher than that in the pre-test for the control group ($t=.99$, $r = .82$, $p > .05$).

21. The mean gain score on Mathematical Creativity is significantly higher for the experimental group than the control group ($t=19$, $p \leq .01$).

22. The mean gain score on Fluency is significantly higher for the experimental group than the control group ($t=15.67$, $p \leq .01$).

23. The mean gain score on Flexibility is significantly higher for experimental group than the control group ($t=17.06$, $p \leq .01$).

24. The mean gain score on Originality is significantly higher for experimental group than the control group ($t=13.54$, $p \leq .01$).

25. The mean gain score on Elaboration is significantly higher for experimental group than the control group ($t=16.24$, $p \leq .01$).

26. The experimental manipulation using 'Package on Geometry' has significant effect on the gain scores on Mathematical Creativity of the upper primary school students when Intelligence and initial level of Mathematical Creativity were controlled ($F= 640.85$, $p \leq .01$ for degrees of freedom (1, 139)).

27. The mean score on Mathematical Creativity is significantly higher in formative test 1 than in pre-test for the experimental group

    ($Mean_{pre\text{-}test}= 10.97$, $Mean_{Formative\ test\ 1} =34.93$).

28. The mean score on Mathematical Creativity is significantly higher in formative test 2 than in formative test 1 for the experimental group

    ($Mean_{Formative\ test\ 1} = 34.93$, $Mean_{Formative\ test\ 2} =48.85$).

29. The 'Package on Geometry' has very large effect on mean gain scores on Mathematical Creativity for the experimental group ($\Delta = 3.79$, $r = .79$).

30. Effect size of the 'Package on Geometry' on mean gain scores on Fluency is very large for the experimental group. ($d = 2.02$, $r = .71$)

31. Effect size of the 'Package on Geometry' on mean gain scores on Flexibility is very large for the experimental group ($d = 2.15$, $r = .73$).

32. Effect size of the ‘Package on Geometry’ on mean gain scores on Originality is very large for the experimental group ($\Delta = 3.99$, $r = .8$)

33. Effect size of the ‘Package on Geometry’ on mean gain scores on Elaboration is very large for the experimental group ($d = 2.36$, $r = .76$).

34. Effect size of the ‘Package on Geometry’ on the mean post-test scores on Mathematical Creativity is very large ($\Delta = 2.79$, $r = .72$).

35. Effect size of the ‘Package on Geometry’ on mean post-test scores on Fluency is very large ($\Delta = 3.12$, $r = .75$).

36. Effect size of the ‘Package on Geometry’ on mean post-test scores on Flexibility is very large ($\Delta = 3.24$, $r = .76$).

37. Effect size of the ‘Package on Geometry’ on mean post-test scores on Originality is large ($\Delta = 1.84$, $r = .6$).

38. Effect size of the ‘Package on Geometry’ on mean post-test scores on Elaboration is very large ($\Delta = 3.2$, $r = .73$).

Tenability of Hypotheses

The tenability of hypotheses was examined on the basis of analysis and its findings.

1. The first hypothesis is stated as ‘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 package (control group)’.

Findings of the study revealed that the experimental group has higher post-test mean scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration than the control group. Hence the first hypothesis is substantiated.

2. The second hypothesis is stated as ‘The post-test mean score on Mathematical Creativity and its components will be significantly higher than the pre-test mean scores for students using the Package on Geometry’.

Findings of the study revealed that the experimental group has higher post-test mean scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration than in the pre-test. Hence the second hypothesis is substantiated.

3. The third hypothesis is stated as ‘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’.

Findings of the study revealed that the post-test mean scores on two components of Mathematical Creativity viz., Flexibility and Elaboration are not significantly higher than that in pre-test for students not using the Package on Geometry. However the post-test mean scores on the other two components of Mathematical Creativity viz., Fluency and Originality and Mathematical

Creativity itself are significantly higher than that in pre-test for students not using the Package on Geometry. Hence the second hypothesis is partially substantiated.

4. The fourth hypothesis is stated as ‘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’.

Findings of the study revealed that the experimental group has higher mean gain scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration than the students not using the package. Hence the fourth hypothesis is substantiated.

5. The fifth hypothesis is stated as ‘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’.

Findings of the study revealed that the experimental group has significantly higher mean gain scores on Mathematical Creativity than that of the students not using the Package on Geometry, when the variation due to Intelligence scores measured through CPM and the pre-test scores on Mathematical Creativity are removed by taking them as covariates. Hence the fifth hypothesis is substantiated.

6. The sixth hypothesis is stated as ‘The mean scores on Mathematical Creativity in the pre-test and the successive tests will significantly differ for students using the Package on Geometry’.

Findings of the study revealed that the mean score on Mathematical Creativity is significantly higher in formative test 1 than in pre-test and formative test 2 than in formative test 1 for the experimental group. That is the mean scores on Mathematical Creativity in the pre-test and the successive tests are significantly different for students using the Package on Geometry. Hence the sixth hypothesis is substantiated.

7. The seventh hypothesis is stated as ‘The Package on Geometry has very large effect on Mathematical Creativity among upper primary school students’.

Findings of the study revealed that the Package on Geometry has very large effect of the gain scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration for the students using the Package. The effect size of the ‘Package on Geometry’ on the mean post-test scores on Mathematical Creativity and its components viz., Fluency, Flexibility and Elaboration, except Originality are very large. For Originality the effect size is large. Hence the seventh hypothesis is partially substantiated.

Conclusions

Students using the Package on Geometry has significantly higher post test mean scores on Mathematical Creativity and its components viz., Fluency, Flexibility, Originality and Elaboration than that of students not using the package which implies that Mathematical Creativity and its components have significantly increased by the implementation of the package. The prevalent education system is good in developing Mathematical Creativity especially for two components Fluency and Originality but only to a smaller amount. However the implementation of 'Package on Geometry' has far reaching impacts in fostering Mathematical Creativity and all its components among upper primary school students. The Flexibility and Elaboration components of Mathematical Creativity are not much influenced by the existing school curriculum. 'Package on Geometry' can be utilized for fostering of all the four components of Mathematical Creativity among the upper primary school students.

The experimental manipulation using 'Package on Geometry' has significant impact on the mean gain scores on Mathematical Creativity and all its components among upper primary school students. The effect of 'Package on Geometry' on the mean scores on Mathematical Creativity of upper primary school students was tested when the Intelligence and initial level of Mathematical Creativity were controlled and found that the model is explaining more variance between the groups. Intelligence is a significant predictor of Mathematical Creativity, whereas the initial level of Mathematical Creativity is not. That is the post-test mean scores on Mathematical Creativity have significantly improved for all upper primary school students who used the package irrespective of their intelligence and initial level of Mathematical Creativity, even though Intelligence is a correlate of Mathematical Creativity. The mean scores on Mathematical Creativity have significantly increased in the first formative test than that of pre-test. The mean difference between first and second formative tests on Mathematical Creativity is also significant. Hence it may be concluded that the level of Mathematical Creativity is gradually increasing among the students who used the package.

The ‘Package on Geometry’ has very large effect on the mean gain scores on Mathematical Creativity and its components. The effect size of the Package on Geometry on the mean post-test scores of Mathematical Creativity and its components viz., Fluency, Flexibility and Elaboration is very large whereas that for Originality is large. Hence the package is highly effective in fostering Mathematical Creativity and all its components among upper primary school students.

Educational Implications

The present study has educational implications in various dimensions especially for parents, teachers, educational administrators and curriculum developers. The implications as noted by the investigator based on the findings are mentioned below.

Present study establishes the effectiveness of the Package on Geometry in fostering Mathematical Creativity among upper primary school students. It is also effective in developing four major components of Mathematical Creativity viz., Fluency, Flexibility, Originality and Elaboration. The package is for instructional purpose but can be managed by parents too regardless of their educational status. The modules are based on the basics of Geometry, but presented in a multimedia approach with a variety of life related activities. The environment during the implementation of the package is student friendly, interactive and challenging. The activities involved are interesting for the proposed population and according to their age level. The present school mathematics curriculum is found to be successful in increasing Mathematical Creativity to some extent but not the flexibility and elaboration. That is, mathematics class room experiences are not helping students think divergently and meaningfully. Hence mathematics teachers must try to follow such an environment in the class room which will make the student think openly, interact freely and participate actively in mathematics learning. Instead of mere drill works, creative ones are to be assigned for home learning. Variety of methods to approach the concept or problem should be encouraged in the class. Mathematics teachers should adopt a flexible approach by bringing novelty to their day-to-day teaching and come up with problems from daily life related concepts. Students must be encouraged to solve them and develop such problems and exchange it with other students. Also allow them to solve mathematical problems by their own methods. Then they will start playing with mathematical concepts which will lead to the development of Mathematical Creativity.

For this, challenging problems with wide scope for generating divergent solutions are to be planned. Also challenging creative life-related tasks are to be planned and learners must get enough opportunities for constructing knowledge. Students are to be encouraged to make still and working models on various mathematical concepts. Other recreational activities such as mathematics quiz, creative work shops, exhibitions, math-lab, etc. to be arranged at schools and students must get opportunities to invent and construct knowledge.

Teachers and parents should not over stress on academic achievement of students; instead they should be allowed to enjoy exploration, innovation and discovery. Obeying elder's decisions silently without questioning sometimes restricts children's choices, harms their interest and kills curiosity.

Teaching method based on technology can sustain students' interest in learning. Multimedia modules can be used for concept clarification and support classroom learning by clarification of difficult topics in various subjects. It saves time and effort in the present scenario of over-loaded syllabus. Creative thoughts can occur in a situation where individuals are thorough and comfortable with respect to the subject matter. Teachers and parents must ensure mastery learning in mathematics among the students at each level. Special programmes for interested students must be organized by the school which is either in the form of self learning or supervised learning that make students think flexibly and with originality.

In the present system, group works are given much importance, along with collective activities; more creative meaningful and participative activities are to be included for the development of creative components in the children. Mishandling of creative, talented buds, inside and outside the classrooms by the adults, especially teachers leads to student violence and misbehaviors. They are not permitted or encouraged to express their original ideas but are forced to keep the strict path followed by all. Package on Geometry can be introduced in classrooms which help to nourish the creative components and to develop better study methods. Similar packages can be developed by the teachers as a collective effort. Ready-made materials and multimedia packages are also available in the market which can be purchased at schools if affordable.

Instead of using such instructional packages separately, these aspects can be included in the school mathematics curriculum and creative tasks can be included as follow up. Enough expertise among teachers for handling these activities must be given through in-service and pre-service training. Adequate references have to be added in the teacher texts.

The classroom experiences make the learner think innovatively and divergently and hence teachers and administrators must be vigilant about the environment in the class room and school as a whole.

Suggestions for Further Research

The findings of the study and the limitations encountered made the investigator suggest the following for further research in this area.

1. The Package was prepared only on geometrical concepts of upper primary level. This can be prepared for other topics in Mathematics such as algebra, arithmetic, statistics etc.

2. Similar instructional packages based on multimedia approach can be attempted for other disciplines such as physics, chemistry, language etc.

3. The Package on Geometry was prepared exclusively for the students of upper primary level. The study can be conducted to students of different levels such as lower primary, high school and higher secondary.

4. Packages can be developed using online platforms like ‘moodle’ for higher standards.

5. Comparison based on gender, religion, socio economic status, locality of residence, locality of school, type of school management, parental involvement etc. can be executed.

6. Other techniques to foster Creativity such as positive learning environment, other innovative learning materials, brain related exercises, techniques, etc. can be experimented in the same way.

7. Different approaches to Mathematical Creativity such as sensitivity, making associations, imagination etc. can be made for the study.

8. In the present study all participants were classified into two levels viz., students using the package and students not using the package. The study can be conducted to investigate the effectiveness of the package at various levels of Creativity such as high, average and low.

9. A survey on the attitude of teachers and students in incorporating similar multimedia packages in classroom learning can be carried out.

JINU M. K. “DEVELOPMENT OF A PACKAGE ON GEOMETRY TO FOSTER MATHEMATICAL CREATIVITY AMONG UPPER PRIMARY STUDENTS”. THESIS. RESEARCH CENTRE IN EDUCATION, FAROOK TRAINING COLLEGE, UNIVERSITY OF CALICUT, 2018.

REFERENCES

REFERENCES

Alam, M. (2009). Academic achievement in relation to creativity and achievement motivation a correlational study. *Edutracks, 8*(3), 31-35.

Albert, A. (2011). When individual differences come into play: The effect of learner creativity on simple and complex task performance. In P. Robinson (Eds.). *Second language task complexity: Researching the cognition hypothesis of language learning and performance (pp.239-266)*. Amsterdam: John Benjamin's publishing Company.

All Stair, K., Howard, H., & Stephen, K. (2002). *Doing statistics with SPSS*. New Delhi: Sage Publication.

Alleck, M. (1937). Approaches to creativity. In S. V. B. Reddy, (2005). *Creativity of student teachers*. New Delhi: Discovery Publishing House.

American Psychological Association. (2009). *Publication manual of American Psychological Association* (6th Ed.) Washington DC.

Anjali, S. (2013). *Role of play schools with regard to the behavioral profile, creativity, problem solving ability and social cognition of pre-schoolers*. (Doctoral Thesis). M. G. University, Kerala.

Arieti, S. (1976). *The magical synthesis*. New York: Basic Books.

Ashalatha, M. (1990). *Problem solving ability in biology of high average and low creative secondary school pupils*. (Unpublished Master's Thesis), University of Calicut, Kerala.

Aurora, R., & Fuentes, C. (2006). Personality: A possible bridge between creativity and psychology. *Creativity Research Journal, 18*(1), 27-38.

Ausubel, D. P. (1963). The *psychology of meaningful verbal learning- An introduction to school learning.* New York: Printice Hall.

Badami, A. (2009). *New enjoying mathematics–class 5*. New Delhi: Oxford University Press.

Badrinath, S., & Sathyanaryanana, S. B. (1979). Correlates of creative thinking of high school students. *Creativity News Letters, 7*, 16-23.

Bahar, A. K., & Maker, C. J. (2011). Exploring the relationship between mathematical creativity and mathematical achievement. *Asia-Pacific Journal of Gifted and Talented Education, 3*(1), 33-48.

Baker, M., & Rudd, R. (2001). Relationship between critical and creative thinking. *Journal of Southern Agricultural Education Research, 51*(1), 120-180.

Balka, D. S. (1974). Creative ability in mathematics. *Arithmetic Teacher, 21*, 633-636.

Balka, D. S. (1974). The Development of an instrument to measure creative ability in Mathematics*. Dissertation Abstracts International, 36* (1), 98-99.

Bandrowski, J. F. (1985). *Creative planning throughout the organization.* New York: American Management Association.

Banerjee, D. (2003). *Self concept and cognitive style creative and non creative students in Calcutta university*. (Doctoral Thesis). University of Calcutta, West Bengal.

Baran, G., Erdogan, S., & Cakmak, A. (2011). A study on the relationship between six-year-old children's creative and mathematical ability. *International Education Studies*, *4*(1), 105-111.

Barron, F. (1965). The creative process and the psychedelic experience, *Explorations Magazine, 4*(2), 48-51.

Barron, F. (1969). *Creative person and creative process,* New York: Rinehart and Winston Inc.

Barron, F., & Harrington, D.M. (1981). Creativity, intelligence and personality. *Annual Review of Psychology, 32,* 439-476.

Bartlett, F.C. (1958). *Thinking: An experimental and social study*. London: Allen & Unwin.

Betty, P. J. (2013). *Mathematical creativity and ability for fundamental mathematical operations of primary school students with dyscalculia*. (Doctoral Thesis). M. G. University, Kerala.

Bhattacharya, P. S. (1956). *A psychological study of the artist.* (Unpublished Master's Thesis). University of Calicut, Kerala.

Bhogayata, C. K. (1998). A study on the relationship among creativity, self-concept & locus of control, *Edutrack, 7*, 25-26.

Bolt, B. (2001). *Mathematical amusement arcade*, New York: Cambridge University Press.

Brannon, J. (2004). *Measuring poetry: A self-study of teacher effectiveness in a twelfth grade advanced placement literature and composition class.* (Master's Thesis). Retrieved from http://etd.lib.fsu.edu/thesis

Bronowski, J. (1972). *Science and human values*. New York: Harper and Row.

Buckeye, D. A. (1970). *The mathematics laboratory: Its effects on achievement, attitude and creativity*. (Master's Thesis). Michigan University. Retrieved from https://www.jstor.org/stable/1170074

Cannatella, H. (2004). Embedding creativity in teaching and learning, *Journal of Aesthetic Education*, *38*(4), 21-28.

Carlton, L. V. (1959). *An analysis of the educational concepts of fourteen outstanding Mathematicians (1790-1940) in the areas of mental growth and development, creative thinking and symbolism and meaning*. (Doctoral dissertation). North Western University, India. Retrieved from https://files.eric.ed.gov/fulltext/EJ1097919

Chantrill, O. (1982). *Workshop to develop skills in module writing.* (1-20, March, 1982), Singapore: Colombo plan Staff London. HMSO College, Cook Croft Committee.

Charyton, C. (2007). General artistic and scientific creativity attributes of engineering and music students. *Creativity Research Journal. 19*, 213-225.

Chemwei, K., & Cheruiyot, Y. (2013). Effects of a learning together model on student's attitude towards school poetry. *Journal of Education and Practice*, *4*(10), 683.

Chen, C., Jiang, B. C., & Hsu, K. (2005). An empirical study of industrial engineering and management curriculum reform in fostering creativity. *European Journal of Engineering Education, 30*(2). Retrieved from http://doi.org/10.180/03043790500087423

Claxton, A. F., Pennels, C. T., & Rhoads, A. P. (2005). Developmental trends in the creativity of school age children. *Creativity Research Journal*, *17*, 327-335.

Cleave, J. V. (1995). *Geometry for every kid*. New York: John Wiley & Sons Inc.

Cohen, J. (1998). *Statistical power for the behavioral sciences*.(2nd Ed.). Hillsdale, New Jersey: Lawrence Erlbaum. Retrieved from http://www.psychometrica.de/effectsize.html

Craft, A., Jeffrey, B., & Leibling, M. (2001). *Creativity in education*. New York: Continuum.

Csikszentmihalyi, M. (2000). Implications of a systems perspective for the study of creativity. In R. J. Sternberg (Ed.). *Handbook of Creativity*, 313-338. Cambridge: Cambridge University Press.

Cutler, A., & Mcshane, R. (2004). *The trachtenberg speed system of basic mathematics*. New Delhi: Rupa & Co. Publishers.

Dahiya, S. S. (1995). *Effect of mastery learning strategy on pupil achievement in mathematics and their creative abilities*. (Doctoral Thesis) M. S. University, Baroda.

Daunis, R., & Scullin, M. (2017). Actigraphy – Defined sleep in relation to laboratory measures of creativity and educational learning. *Sleep*, *40*(1). 80-82.

De Bono, E. (1992). *Six thinking hats for schools: Resource book*. Melbourne: Hawker Brownlaw Education.

Devi, S. (2007). *Awaken the math genius in your child.* Retrieved from http//:www.discovery education.com/puzzlemaker

Dutta, K. C. (1989). *Differences in scientific creativity among high school students*. (Doctoral Thesis). University of Jammu, India. Retrieved from http://shodhganga.inflibnet.ac.in/bitstream/10603/26998/10/10

Erhart, M. M. (1960). Arithmetic for the academically talented. *Arithmetic Teacher, 7,* 53-60.

Ervynck, G. (1991). *Mathematical creativity: Advanced mathematical thinking,* New York: Khuwer Academic publishers.

Evans, E. W. (1965). *Measuring the ability of students to respond in creative mathematical situations at the late elementary and early junior high school level*. (Doctoral dissertation). University of Michigan. Retrieved from https://journals.sagepub.com/doi/abs/10.3102/00346543043004405

Eysenck, H. J. (1995). *Genius: The natural history of creativity*. Cambridge: Cambridge University Press.

Field, A. (2005). *Discovering statistics using SPSS*. London: Sage Publications.

Finke, R. (1992). *Creative imagery, discoveries and inventions in visualization.* Hillsdale: Lawrence Erlbaum.

Fisher, R. (2004). What is creativity?. In R. Fisher & M. Williams (Eds.). *Unlocking creativity: Teaching across the curriculum.* London: David Fulton Publishers.

Fleith, D. (2014). Measurement of mathematical creativity. In S. Alencar, M. Bruno-Faria & D. Fleith. *Theory and practice of creativity measurement*. Brazil: Prufrock Press Inc.

Foster, J. (1970). An exploratory attempt to assess creative ability in mathematics, *Primary Mathematics, 8,* 2-7.

Freud, S. (1915). *The unconscious*. New York: Standard Edition.

Freud, S. (1976). Creative writers and day dreaming. In A. Rothenberg & C. R. Lauman (Eds.), *The creativity question* (pp.48-54). USA: Duke University Press.

Fritz, R. (1991). *Creating*. New York: Fawcett.

Gabora, L. (1997). The origin and evolution of culture and creativity: Evolutionary models of information transmission. *Journal of Mathematics*, *1*(1), 54-59.

Gagne, R. M., & Briggs, L. G. (1973). *Principles of instructional design*. New York: Holt Renehart & Winston Inc.

Gallian, J. A. (1994). *Contemporary abstract algebra*. Lexington, United Kingdom: D C Health & Co.

Galton, F. (1870). *Hereditary genius: An inquiry into its laws and consequences*. New York: Appleton & Co.

Garber, J. A., Resmick, T., Kepees, M., & Vedhan, V. (1979). Levels of creative thinking in pre-school age children from orthodox and non-orthodox homes. *Journal of Psychology and Judaism, 3*, 217-226.

Gardner, H. (1994). *Creative minds*. New York: Basic Books.

Garrett, E. H. (2004). *Statistics in psychology and education*. New York: Paragon International Publishers.

Gautam, A., & Kulshrestha, A. K. (2011). New paradigm in education: Constructivist approach. *Edutracks*, *10* (7), 17-21.

Gaylie, V. A. (2003). *A study on challenging the underpinnings of language learning and literacy: A poetic counter narrative*. (Doctoral Dessertation). Retrieved from http://hdl.handle.net

George, T. (1994). *A study of the mathematical creativity of secondary school Students in relation to their intelligence and maths achievement.* (Unpublished M. Phil Thesis). Kerala University, Kerala.

Getzels, J. W. (1961). Family environment and cognitive styles: A study of the sources of highly intelligence and highly creative adolescents. *American Psychological Review*, *26*, 351-359.

Getzels, J. W., & Jackson, P.W. (1962). *Creativity and intelligence exploration with gifted students.* New York: John Wiley Publishers.

Ghosh, J. B., Gandhi, H., & Kaur, T. (2010). *Hands on maths for class seven.* Patna, Bihar: Bharati Bhavan Publishers and Distributors.

Good, C. V. (1972). *Dictionary of Education*. Book Co. Centre of Advanced Study in Education, New York: Mc Graw Hill.

Goyal, P. L. (2014). *N'rich – Mental mathematics.* New Delhi: Neeta Prakashan.

Guilford, J. P. (1950). Creativity. *American Psychologist*, *5*, 444-454.

Guilford, J. P. (1967). *The nature of human intelligence*. New York: McGraw-Hill.

Guilford, J. P. (2007). *General Psychology*. New York: McGraw-Hill.

Gulati, S. (1997*). Understanding creative psychometric view*, New Delhi: Commonwealth Publishers.

Gupta, B. (2012). Effect of socio-demographic factors on creativity and intelligence of senior secondary students. *Edusearch, 3*(1), 107-111.

Hadamard, J. (1945). *The psychology of invention in the mathematical field.* New York: Mineola.

Hadamard, J. (1954). Lessons in geometry*, American mathematical society,* 6, 41-54.

Haddon, F. A., & Lytton, H. (1968). Teaching approach and the development of divergent thinking abilities in primary schools. *British Journal of Educational Psychology*. *38*(1), 171-80.

Haggard, E. A. (1957). Socialisation, personality and academic achievement in gifted children. *School Review, 65,* 388-414.

Halber, D. (1999). Different kinds of math use different parts of brain. *MIT Tech Talk*, *43*(30), 52-59.

Haylock, D. (1997). Recognizing mathematical creativity in school children. *International Reviews on Mathematical Education, 29*(3), 68-74.

Haylock, D. W. (1984). *Aspects of mathematical creativity in children aged 11-12.* (Doctoral dissertation, University of London). British Thesis Service, The British Library System No. 0009803014.

Haylock, D. W. (1987). A framework for assessing mathematical creativity in school children. *Education Studies in Mathematics, 18(*1), 59-74.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods of meta-analysis.* Sandiago: Academic Press. Retrieved from http://www.psychometrica.de/effectsize

Heinich, R. (1990). *Instructional media and the new technology of instruction*. Retrieved from http://researchgate.net/modular-approach

Helie, S., & Sun, R. (2010). Incubation, insight and creative problem solving. *Psychological Review at American Psychological Association*, *117*(3), 994-1024.

Henderson, K. B., & Pingry, R. E. (1953). Problem solving in mathematics. *The learning of Mathematics. 21*, 228-270.

Hermmelin, B., & O'conor, N. (1986). Mathematical creativity of gifted children *Journal of Humanistic Psychology*, *12*(2), 23-28.

Hilal, A., & Omer, E. (2008). *The effect of scientific process skills education on students scientific creativity, science attitudes and academic achievements*. (Doctoral Thesis). University of Dokuz Eylul, Turkey.

Hong, E., & Aqui, Y. (2004). Cognitive and motivational characteristics of adolescents gifted in mathematics: Comparison among students with different types of giftedness. *The Gifted Child Quarterly, 48* (3), 191-201.

Hong, E., Hartzell, S. A., & Greene, M. T. (2011). Fostering creativity in classroom: Effects of teacher's epistemological beliefs, motivation and goal orientation. *Journal of Creative Behaviour*, *43*(3), 192-208.

Hu, W., & Adey, P. A. (2002). A Scientific creativity test for secondary school students. *International Journal of Science Education*, *24*(4), 389-403.

Hu, W., Adey, P., & Shen, J. (2003). The influence of CASE on scientific creativity. *Research in Science Education, 33*(2): 143-162.

Hussain, S. (1988). *Creativity concept and findings*. New Delhi: Motilal Banarsidas.

Ismail, M. (2007). Effect of certain strategies of teaching English on nurturing creativity of higher secondary school students. *Asia Pacific Forum on Science Learning and Teaching, 9(*1), 1-21.

Jacob, A. K. (2007). Relationship between creativity and self concept. *Edutrack*, *7*(2), 25-26.

Jain, S. (1992). *A study of creativity in relation to the teaching aptitude, skills & personality variables of pupil teacher.* (Doctoral Thesis). Nagpur University, Maharashtra. Retrieved from ERIC data base (EJ078372)

Jaleel, S., & Titus, B. (2015). Effectiveness of gaming strategy on mathematical creativity of students at secondary level. *Indian Journal of Applied Research,* 5(10), 35-37.

Jayaram, K. (2013). *Qualification, teaching and creativity score among secondary school pupils.* (Unpublished Masters Dissertation.) University of Calicut, Kerala.

Jayasree, S. U. (1988). *Effect of select attitude variables on creativity among secondary school pupils*. (Unpublished Masters Dissertation). University of Calicut., Kerala

Jensen, L. R. (1973). *The relationships among mathematical creativity, numerical aptitude and mathematical achievement.* Dissertation Abstracts International, 34 (05), 2168. Retrieved from ERIC data base (EJ086530).

Joshi, R. J. (1981). *A study of creativity and personality traits of the intellectually gifted children.* (Unpublished Doctoral dissertation). M. S. University, Baroda. Retrieved from http://shodhganga.inflibnet.ac.in/bitstream/10603/60570/10/10

Jyothilekshmi, J. R. (2004). *Comparative study of mathematical aptitude, spatial ability and mathematical ability of secondary school students studying in government aided and unaided institutions follow state, CBSE and ICSE Syllabus.* (Unpublished Master's Dissertation). Kerala University, Kerala.

Kanhai, A., & Singh, B., (2016). Some environmental and attitudinal characteristics as predictors of mathematical creativity. *International Journal of Mathematical Education in Science and Technology, 48*(3), 327-337.

Karagulla, S. (1970). *Break through to creativity*. Los Angeles, California: Devorss & Co. Inc.

Kaur, R. (1991). Effectiveness of Bruner and Ausubel models for teaching of concepts in economics to high and low achieving students across creative levels. In B. K. Passi (1982). *An exploratory study of creativity and its relationship with intelligence and achievement in school subjects at higher secondary stage*. (Doctoral Dissertation). Punjab University, Punjab.

Kavitha, M. (2009). *Interaction effect of Mathematical Creativity, Intelligence and problem solving ability on achievement in Mathematics of IX standard students of Banglore Distrcit.* (Doctoral Thesis). Alagappa University, Tamilnadu. Retrieved from https://files.eric.ed.gov/fulltext/ED506983.pdf

Kelley, K., & Preacher, K. J. (2012). On effect size. *Psychological methods, 17*(2), 137-152.

Khatib, M. (2011). A new approach to teaching English poetry to students. *Journal of Language Teaching and Research, 1(*2), 164-169.

Kim, H. J., Park, J. H., Yoo, S., & Kim, H. (2016). Fostering creativity in tablet-based interactive classrooms. *Educational Technology & Society, 19* (3), 207-220.

Kim, K. H. (2008). Underachievement and creativity: Are gifted under-achievers highly creative?. *Creativity Journal, 20,* 234-242.

Kim, K. H., & Lee, H. (2004). *Cultural influence on creativity: Relationship between creativity and confucianism.* (Doctoral Thesis). University of Georgia, Athens.

Koberg, D., & Bagnall, J. (1981). *The all new universal traveler: A soft-systems guide to creativity, problem-solving, and the process of reaching goals*. Los Altos, CA: William Kaufmann. Inc.

Kochunarayanan, T. K. (2008). *Kanakku: Varayum kuriyum*. Thiruvananthapuram, Kerala: Kerala State Institute of Languages.

Koestler, A. (1964*). The act of creation.* London: Hutchinson & Co.

Kong, F. (2010). On the effectiveness of applying English poetry to extensive reading teaching. *Journal of Language Teaching and Research, 1*(6), 918-921.

Kumari, A. V. (1992). Relationship between creativity in science and certain demographic variables of primary school pupils. (Unpublished Master's Dissertation). University of Calicut, Kerala.

Kurtzberg, T. R. (2005). Feeling creative, being creative: An empirical study of diversity and creativity in teams. *Creativity Research Journal, 17*, 51-65.

Kuveri, F. (2013). *Effectiveness of concept mapping on scientific creativity among secondary school children. (*Unpublished Master's Thesis). University of Calicut, Kerala.

Lanier, P. E. (1967). *A study of creativity, Intelligence and discovery teaching as related to performance in elementary School Mathematics*. (Doctoral Thesis). University of Oklahoma, USA. Retrieved from https://www.jstor.org/stable/1170074

Laycock, M. (1970). Creative mathematics at nueva. *Arithmetic Teacher, 17*, 325-328.

Leikin, R. (2010). Teaching mathematically gifted. *Gifted Education International, 27*, 161-175.

Leikin, R. (2011). The education of mathematically gifted students: On some complexities and questions. *Montana Mathematical Enthusiast Journal, 8*, 167- 188.

Leikin, R., & Lev, M. (2007). *Multiple solution task as a magnifying glass for observation of mathematical creativity*. (pp.167-174). Proceedings of the 31st conference of the international group for the psychology of mathematics education. Retrieved from http://ermeweb.free.Fr/Cerme5.pdf

Lester, F. K. (1985). Methodological considerations in research on mathematical problem solving. In E. A. Silver (Eds.) *Teaching and learning mathematical problem solving: Multiple research perspectives.* (PP. 41-70). Hills dale: New Jersy: Erlbaum.

Levin, M. J. (1978). *Psychology: A biographical approach*, New York: McGraw Hill.

Liu, C. C., Lu, K. H., Wu, L.Y., & Tsai, C.C. (2016). The impact of peer review on creative self-efficiency and learning performance in web 2.0 learning activities. *Educational Technology & Society, 19* (2), 286-297.

Mackinnon , D. W. (1961). *The creative person*. New York: Penguin Books.

Mackinnon, D. W. (1962). The nature and nature of creative talent. *American Psychologist*, 17, 484-495.

Mackinnon, D. W. (1966). What makes a person creative?. *Theory into practical, 5(*1), 152-156.

Mahapatra, P. (2000). Developing creative expression in elementary grades through enrichment programmes. *Journal of All India Association for Educational Research*, 12(3&4), 72-78.

Mainville, W. E. (1972). *A study of the effect of Mathematics activity materials upon certain aspects of creative thinking ability of prospective elementary School teachers*. (Doctoral dissertation). University of Maine. Retrieved from http://link.springer.com

Manoj, M. S. (2008). *Rasikan ganitham*. Kozhikode, Kerala: Poorna Publications.

Mansfield & Buse (1981). In R. Reddy (2005). *Creativity of Student Teachers*, Discovery Publishing House, New Delhi.

Mathematics: Standard V. (Part 2). (2012). Kochi, Kerala: Department of Education, Government of Kerala.

Mathematics: Standard V. (Part I) (2013). Kochi, Kerala: Department of Education, Government of Kerala.

Mathematics: Textbook for class VI. (2006). New Delhi: Publication Division, NCERT.

Mathematics: Textbook for class VII. (2006). New Delhi: Yash Pal and Rahul Pal Publication, NCERT.

Mathew, T. K., (1986). *An investigation into the relationship between adjustment, creativity and achievement in chemistry of secondary school students of* Kerala. (Unpublished Master's Thesis). University of Calicut, Kerala.

Math-Magic: Textbook in mathematics for class V. (2008). New Delhi: Publication Department, NCERT.

Meconi, L. J. (1967). The Mathematically gifted student and discovery learning. *Mathematics Teacher, 60,* 862-865.

Mednick, S. A. (1961). Development of admission criteria for colleges & universities, in current issues in higher education, *National Education Association*, 87-89.

Mednick, S. H. (1964). An associative interpretation of the creative process. In C. W. Taylor (Eds.) *Widening Horizons in creativity*. New York: John Wiley and sons Inc.

Meera, K. P., & Menon, S. (2008). Effectiveness of synectics model of teaching on the creativity of higher secondary school students. *International Educator*, *20*(1), 220-226.

Mehdi, S., & Baqer, R. (1989). *Verbal and non-verbal tests of creative thinking*. Agra: National Psychological Corporation.

Menon, P. R. (2004). *Kanakkinte kumilakal*, Thrissur, Kerala: Kerala Sasthra Sahithya Parishat.

Merrifield, P. R., Guilford, J. P., Christensen, P. R., & Frick, J. W. (1961). Iterates below certain abilities and certain traits of motivation and temperament. *Journal of General Psychology*, *65*, 57-74.

Meyer, R. W. (1970). *The identification and encouragement of mathematical creativity in first grade students.* (Doctoral Thesis). University of Wisconsin. Retrieved from https://www.jstor.org/stable/3482505

Midhundas, A. M., & Vijayakumari, K. (2016). *Influence of mathematics anxiety on mathematical creativity among secondary school students. Guru Journal of Behavioural and Social Sciences. 4* (142), 495-502.

Midhundas, A. M., & Vijayakumari, K. (2017). *Influence of optimism on mathematical creativity of secondary school students.* Compendium of AIAER Annual Cum International Conference.

Moltafet, G., Firoozabadi, S. & Raisi, A.P. (2018). Parenting style, basic psychological needs and emotional creativity: A path analysis, *Creativity Research Journal*, *30*(2), 187-194.

Moravcsik, M. J. (1981). Creativity in science education. *Science Education*, *65*(2), 221 – 227.

Muller, R. (2004). *Math teasers,* New Delhi: Orient Paper backs.

Naja, S. (1989). *An investigation into the relationship between the factors of creativity and achievement in Mathematics of ninth standard pupils of Thrissur and Palakkad revenue district*. (Unpublished Master's Thesis). University of Calicut, Kerala.

Newell , A., Shaw, J. C., & Simon, H. A. (1962). The process of creative thinking. In H. E. Gruber, G. Terrel & M. Wertheimer (Eds.), *Contemporary approaches to creative thinking.* New York: Mc Grow Hill.

Nisha, S. R. (2010). *A study of the influence of commercialized learning materials for developing creativity in Mathematics in secondary school students.* (Unpublished Master's Thesis). Kerala University, Kerala.

Oden, M. H. (1968). The fulfillment of promise: Forty years follow up of German gifted group. *Genetic Psychology Monograph, 77,* 3-93.

Osborn, A. F. (1953). *Applied imagination, principles & procedures of creative thinking.* New York: Scribner.

Oxford Dictionary (2003). Oxford, London: Oxford University Press.

Parnes, S. J. (1992). *Sourcebook for creative problem solving.* Buffalo, New York: Creative Education Foundation Press.

Passi, B. K. (1982). *An exploratory study of creativity and its relationship with intelligence and achievement in school subjects at higher secondary stage*. (Doctoral Dissertation). Punjab University, Punjab. http://shodhganga.inflibnet.ac.in/bitstream/10603/61276/8/08

Pescarmona, I., (2011). Creativity and competencies in experimenting with complex instruction: From the pupil's perspective. *Experiments in Education, 7,* 81-89.

Philips, S. (2012). *Amazing math puzzles: Skill builders*. New Delhi: Goodwill Publishing House.

Piaget, J., (1926). *Judgment and reasoning in the child.* New York: Harcourt & Brace.

Plsek, P. E. (1996). *Models for the creative process.* Retrieved from http://directedcreativity.com

Plucker, J. A., & Renzuli, J. S. (1999). *Psychometric approaches to the study of human creativity*. New York: Cambridge University Press.

Poincare, H. (1924). Mathematical creation, Science method. *Science Press, 3,*83-94.

Poincare, H. (1948). *Science and method*. New York: Dover.

Poincare, H. (1956). *Mathematical creation: The world mathematics*. (Vol.IV). New York: Simon and Schuster.

Polya, G. (1954). *Mathematics and plausible reasoning: Induction and analogy in mathematics (Vol. II).* Princeton, New Jersy: Princeton University Press.

Prasad, B. A. (1993). Sex difference in creativity: a study in navodaya vidyalayas. *Indian Educational Abstracts, 19*(2), 20-25.

Prieto, M. D. & Sanchez, C. (2005). *Intelligence and creativity*. Retrieved from www.ipisr.org.rs

Prouse, H. L. (1967). Creativity in school mathematics. *Mathematics Teacher, 60,* 876-879.

Punoose, P. (2004). *Kanakku vinodangalilude*. Kottayam, Kerala: Current books.

Rao, G. N. (2005). How learning disability occur in a child. *Edutracks, 7*, 10-11.

Raven, J. C. (1995). *Advanced progressive matrices – Set II*, Oxford, England: Oxford Psychologists Press J.C. Raven Ltd.

Rawat, T. C., & Kumar, S. (2012). Examining the originality component of scientific creativity talent of elementary state students of Himachal pradesh. *An International Journal of Education, 3*(2), 55-62.

Reddy, B. S. V. (2008). Creativity of student teachers of colleges of education. *Edutracks*, *7(*1), 12-13.

Renzulli, J. S. (1978). What makes giftedness? Re-examining a definition, Phi Delta, *Kappan, 60*, 180-184.

Resmi, S. (1997). *Interaction effect of mathematics study approach and mathematical creativity on achievement in mathematics of secondary school pupil in Kerala.* (Unpublished Master's Dissertation). University of Calicut, Kerala.

Romey, W. D. (1970). What is your creativity quotient*?. School Science and Mathematics*, *70*, 3-8.

Rossman, J. (1931). *The psychology of the inventor.* Washington DC: Inventor's Publishing.

Sak, U., & Maker, C. J. (2006) Developmental variations in children's creative mathematical thinking as a function of schooling, age, and knowledge. *Creativity Research Journal*, *18*(3), 279-291.

Sarsani, M. R. (2006). *Creativity in schools*, New Delhi: Sarup & Sons.

Schoenfeld, A.H. (1985). *Mathematical problem solving.* New York: Academic Press.

Sebastian, N. (2013). Relationship between mathematical creativity achievements in mathematics of secondary school pupil. *Journal of Studies in Teacher Education. 61 (*1). 66-69.

Sharma, Y. (2013). Mathematical creativity: Exploring the effects of divergent mathematical exercises and creativity. *Experiments in Education, 18*(2), 5-11.

Sheffield, L. J. (2006). Developing mathematical promise and creativity. *Journal of the Korea Society of Mathematics Education Series D: Research in Mathematics Education, 10*(1), 1-11.

Singer, F. M. (2016). Cognitive styles in posing geometry problems: Implications for assessment of mathematical creativity. *Mathematics Education, 49*, 37-52.

Singer, F. M., & Voica, C. (2015). Is problem posing a tool for identifying and developing mathematical creativity?. *Research in Mathematics Education book Services,* 5, 141-174.

Singh, A, (2013). Predicting academic achievement on the basis of achievement motivation, emotional intelligence and creativity of student teachers. *Journal of Educational Research and Extension, 50*(1), 25-34.

Singh, B. (1988). *Teaching-learning Strategies & Mathematical creativity*. New Delhi: Mithal.

Sinnott, E. W. (1959). *The creativeness of life*. Retrieved from (EJ854978).

Slavica, M. (2004). *Creativity of students' stories: Case study at primary level*. Retrieved from www.ipisr.org.rs

Smogorzewska, J. (2014). Developing children's language creativity through telling stories – An experimental study. *Thinking Skills and Creativity*. *12*, 20-31.

Sousa, D. A. (2000). *How the brain learns*. California: Corwin Press Inc.

Sousa, D. A., (2001). How the brain learns: A Classroom teacher's guide. California: Corwin.

Spraker, H. S. (1960). *A study of the comparative emergence of creative behavior during the process of group and individual study of Mathematics*. (Doctoral dissertation). University of Virginia. Retrieved http://dx.doi.org/10.1016/ j.tsc.2014.02.2005

Sravan, P. (2015, September 22). The beauty of the concept of mathematics. *The Hindu Daily*.

Sreedharan, P. (2008). *Tangram kali : Kalikalude rajavu*. Kottayam, Kerala: D. C. Books.

Sreedharan, P. (2009). *Veda ganitham*. Kottayam, Kerala: D. C. Books.

Sreedharan, P. (2010). *Soundaryathinte ganitha sasthram*. Kannur, Kerala: Samayam Publications.

Sreekala, C. (1991). *Effect of certain attitude variables and intelligence on creativity of secondary school pupil of Kerala.* (Unpublished Master's Dissertation). University of Calicut, Kerala.

Sreekant, Y. (2004). Societal role in development of creativity children. *Edutracks, 6*(2), 14-05.

Sreenivas, K. (2013). Effectiveness of constructivist approach on the achievement in science of nineth standard students. *Edutracks* 12(9), 18-23.

Sreerekha, R. (2001). *A study of relationship between self-concept, intelligence, mathematical creativity and achievement in mathematics of secondary school pupils.* (Unpublished Master's Dissertation). Kerala University, Trivandrum.

Sriraman, B. (2004). The characteristics of mathematical creativity. *The International Journal on Mathematics Education, 41*, 13-27.

Sriraman, B. (2005). Are giftedness and creativity synonyms in mathematics? An analysis of constructs within the professional and school realm. *The Journal of Secondary Gifted Education, 17*, 20-36.

Srivastava, S. S. (1977). Creativity as related to birth order and number of siblings. *Indian Psychological Review, 14*, 1-4.

Stangroom, J. (2016). *Effect size calculation.* Retrieved from http://socscistatistics.com

Sternberg, R. J. (2000). *Handbook of creativity*. Cambridge, UK: Cambridge University Press..

Sternberg, R. J., & Lubart, T. I. (1995). Investing creativity. *American Psychologist 51*(7), 677-688.

Sternberg, R. J., (1988). *The nature of creativity: Contemporary psychology perspectives.* Cambridge, London: Cambridge University Press.

Sukla, J. P., & Sharma. V. P. (1987). A cross cultural study of scientific creativity. *Indian Journal of Applied Psychology, 24*(2), 101-106.

Sumangala, V., (1987). *A comprehensive test of creativity*. Dept. of Education, University of Calicut, Kerala.

Summers, G. J. (1989). *Puzzles and teasers*. New York: Jaico Publishing House.

Summers, G. J. (2008). *Puzzles and teasers*. New York: Sterling Publishing Co.

Syh – Jong, J., (2010). The impact on incorporating collaborative concept mapping with co-teaching techniques in elementary science classes. *School science and Mathematics, 110* (2), 86 -97.

Talawar, M. S., & Madhusudhanan, K. (2010). Mathematical creativity among secondary school students: A study. *International Educator*, *22*, 42-47.

Thankarajathi, S. (2008). Effectiveness of mind mapping technique in teaching mathematics. *Edutracks, 8*(3), 26-29.

Thurstone, L. L. (1952). *Creative talent: Applications of psychology*. New York : Harper & Row.

Topno, I. (2014). E*motional intelligence creativity and teacher effectiveness of primary school teachers.* (Unpublished Master's Thesis). Manonnmanian Sundaranar University, Tamil Nadu. Retrieved from http://shodhganga.inflibnet.ac.in /handle/10603/23996

Torrance, E. P. (1960). *Guiding creative talent*. Eaglewood Cliffs, New Jersy: Prentice Hall.

Torrance, E. P. (1966). *Torrance test of creative thinking* –Direction mannual and scoring guide. New Jersey: Personal press.

Torrance, E. P. (1967). *Creativity and its educational implications.* New Jersy: John Willey and Sons.

Torrance, E. P. (1969). *Encouraging creativity in the classroom*. Minneapolis: Minnesota University Press.

Torrance, E. P. (1980). Growing up creatively gifted. *The Creative Child and Adult Quarterly*, *3*, 148-158.

Treffinger, D. J. (1969). Developing creative problem solving abilities & related attitudes through programmed instruction. *Journal of Creative Behavior*, 105-114.

Tuli, M. R. (1980). Mathematical creativity as related to aptitude for achievement in and attitude towards mathematics. *Dissertation Abstracts International, 42* (1), 122-125.

Tyagi, T. K. (2014). Is there a casual relation between mathematical creativity and mathematical problem solving performance?. *International Journal of Mathematics Education in Science and Technology,* 1-7. doi:10.108010020739x.2015.107561.

Tyagi, T. K. (2017) Mathematical intelligence and mathematical creativity. A causal relationship. *Creativity Research Journal*, 29 (2), 212 -217.

Upadhyaya, S. K. (2011). A study of creativity in relation to socio-economic status of high school students. *Journal of Educational Research and Extension, 48*(1), 105-112.

Vandana, P. (2012*). Relationship between mathematical creativity and mathematical intelligence.* (Unpublished Master's Dissertation). Banaras Hindu University, Varanasi.

Varghese, V. B. (1998). *Creativity in English language teaching*. New Delhi: Anmol Publications.

Vasugi, K., & Kalavathy, K. P. (2008). Scientific creativity among high school students of Dindigul district: Survey. *Experiments in Education, 10*(3), 11-14.

Venables, D. R. (2009). *Which-did-you-prefer-algebra-or geometry*?. Teachers count word press. Retrieved from http://learnweb.harvard.edu

Vernon, P. E. (1976). *Creativity*. New York: Penguin Books.

Vijayakumari, K., & Kavithamole, M. G. (2014). Mind mapping: A tool for mathematical creativity. *Guru Journal of Behavioral and Social Sciences 2*(1), 241-246.

Vijitha, P. (2016). *Influence of spatial ability on mathematical creativity of higher secondary school students of Kerala.* (Unpublished Master's Thesis). University of Calicut, Kerala.

Vinache, E. W. (1952). *The psychology of thinking*. New York: McGraw-Hill.

Wallach, M. A., & Kogan, N. (1965). *Modes of thinking in young children*. New York: Holt, Rinehart & Winston.

Wallas, G., (1926). *The art of thought*. New York: Harcourt Brace.

Ward. K. (2003). Entrepreneurialism urbanism: State Restructuring and civilizing. *International Journal of Urban and Regional Research, 35*, 116-127.

Weisberg, R. W. (1993). *Creativity: Beyond the myth of genius.* New York: Freeman.

Wertheimer, M. (1945). *Productive thinking.* New York: Harper & Rwo.

Whitecombe, A. (1988). Mathematics: Creativity, imagination, beauty. *Mathematics in School, 17,* 13-15.

Wiles, J., & Bonondi, J. (1989). *Curriculum development*. New York: Merril Publishing Company.

Yadav, S. K., & Wadhwa, S. (2011). Creativity and academic achievement of adolescents studying in English medium and Hindi medium schools. *Journal of Educational Research and Extention*, *48*(1), 119-125.

Yeh, Y., & Lin, C. F. (2015). Aptitude-treatment interactions during creativity training in e-learning: How meaning-making, self-regulation, and knowledge management influence creativity. *Educational Technology & Society*, *18* (1), 119-131.

Yeh, Y., & Lin, C. S. (2017). *Achieved goals influence mastery experience via two paths in digital creativity games among elementary school students*. John Wiley & Sons Ltd. Retrieved from Wiley online library.com.

APPENDICES

Appendix A_1

Details of the Participants for the Experiment

School	**Class**	Gender			**N**	
CMGHSS, Kuttur, Thrissur	Sixth	Male	23	35	70	
		Female	12			
	Seventh	Male	19	35		
		Female	16			140
GVHSS, Machad, Thrissur	Sixth	Male	17	35	70	
		Female	18			
	Seventh	Male	14	35		
		Female	21			

Appendix A_2

Details of the participants for the Pilot study

Sl. No.	Name of School	Type of Management	Gender	
			Boys	Girls
1	GHSS, Villadom, Thrissur District	Government	15	15
2	Nirmala HSS, Ayyanthol, Thrissur District	Aided	18	18
3	St. Thomas HSS, Thiroor,	Aided	15	15
4	GHSS, Punkunnam, Thrissur District	Government	15	15
5	Marymatha HSS, Panthalampadom, Palakkad District	Aided	17	17
6	GHSS, Kunissery, Palakkad District	Government	16	16
7	GHSS, Kottayi, Palakkad District	Government	14	14
8	PKHS, Manjapra, Palakkad District	Aided	15	15

Appendix B

Intelligence Test- specimen copy (sets A, Ab and B)

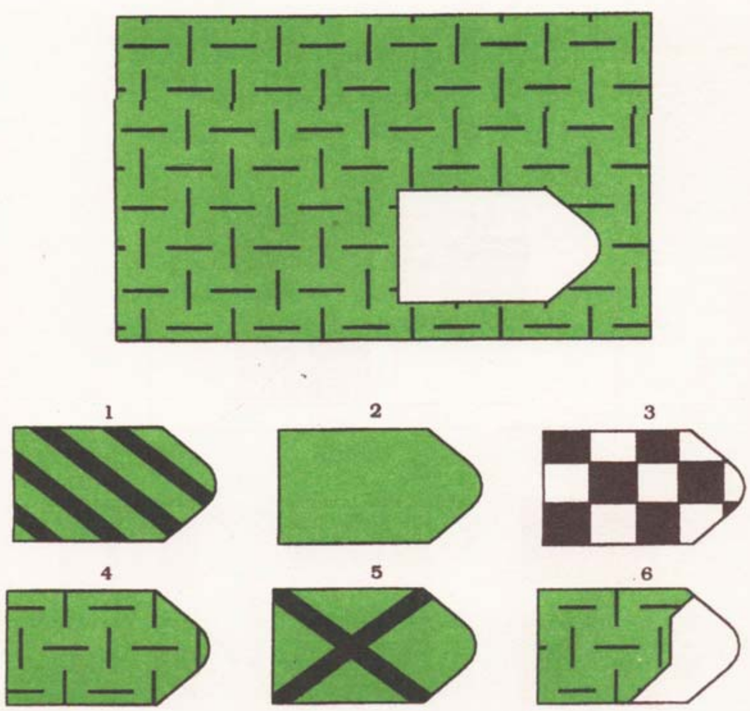
Specimen copy of each set is attached in next pages with description.

SET A.

The set includes rather simple problems. The correct answer figure can be selected from the four alternatives and the selected are will well fit into the pattern giving it a definite shape. A specimen from set A is given below

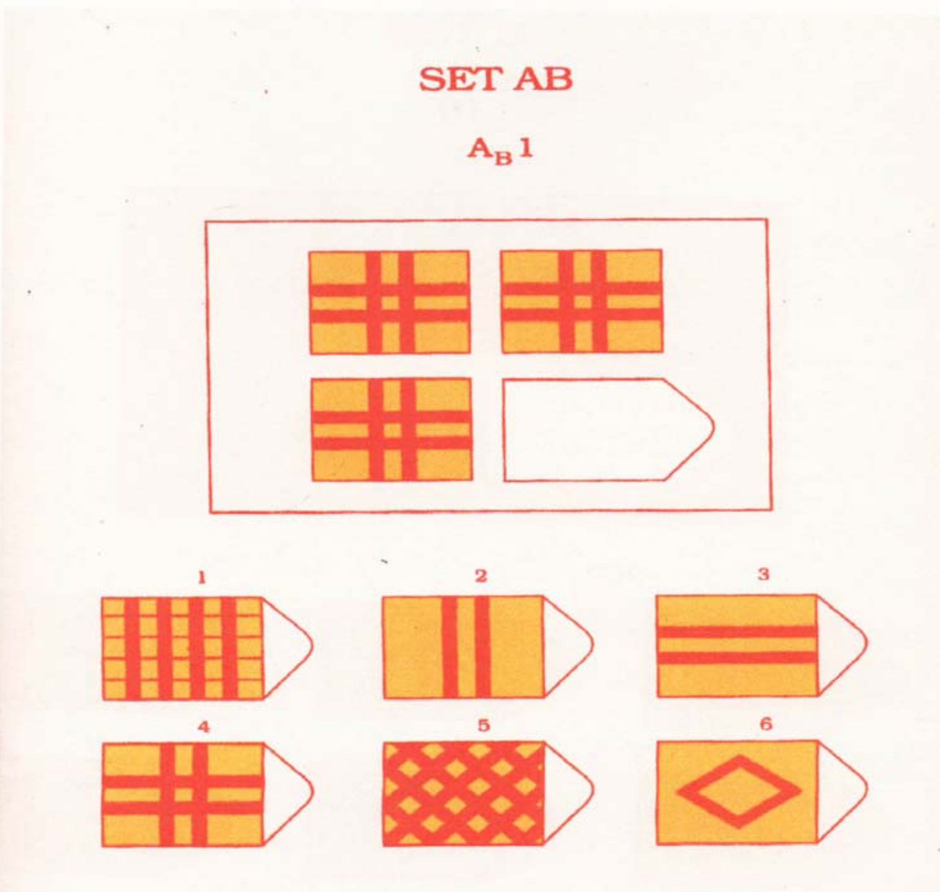
SET A

A1



SET Ab

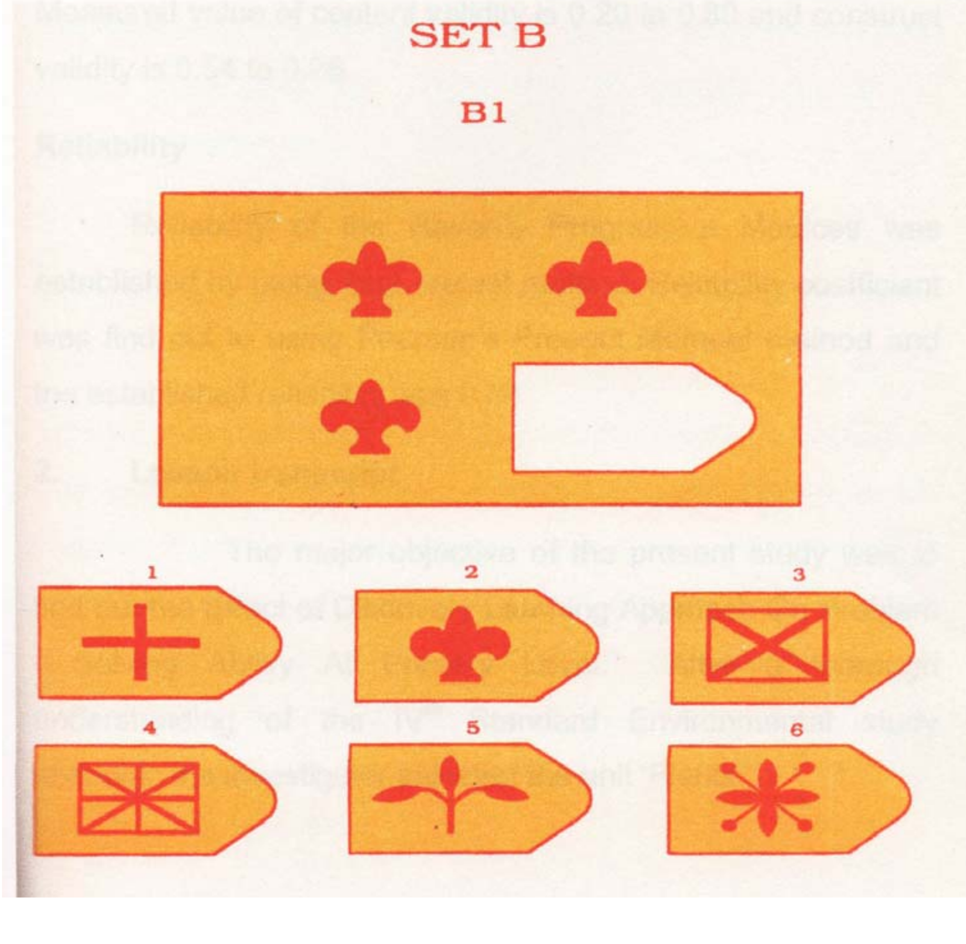
Problem in the set Ab includes simple problem. The set also consisted of four alternative and the selected one will well fit into the pattern giving, It a definite shape. A specimen from the Set Ab is given below.



SET B

The problem in the Set B is also very easy to understand. The answer figure to these problem are some what identical to the element given in the pattern in some problem the answer given (figure), can also be derived as the mirror image of the element which is printed at the top position.

A specimen figure from set B is given below.



Appendix C

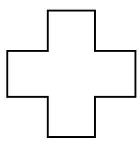
MATHEMATICAL CREATIVITY PRE-TEST (DRAFT)

Standard: 5, 6, 7 Time:60 minutes

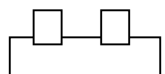
Instructions for all the questions you can give as many responses as you can. Also try to name or describe the use of the item in your own words. Please ensure your response for each question. Your responses will be used for research purpose only.

1. Construct different meaningful figures using the cut pieces formed by cutting the figure with only two straight lines. Also name them.

(7 minutes)

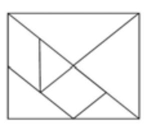


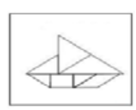
Eg. Setty



2. Restructure the pieces of the following figure to form different objects. Also name them.

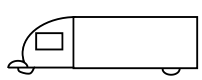
(5 minutes)





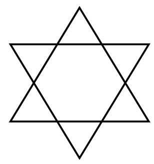
Eg: Boat

3. Using different geometrical shapes draw a vehicle of your choice and mark the geometrical shapes included in it. (Try to include different types of geometrical shapes). (7 minutes)



Eg: Autorikshaw

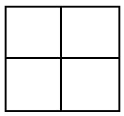
4. Using maximum six points draw various patterns and name it with the familiar shapes.



(5 minutes)

Eg: Star

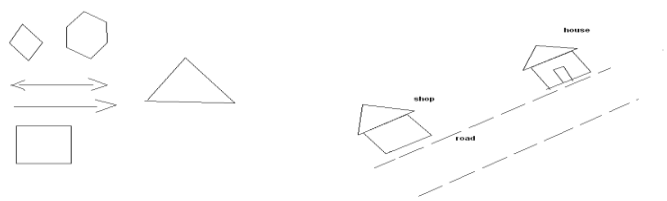
5. Arrange four squares to design objects. Also write the names of the constructed figures.



Eg. Window (5 minutes)

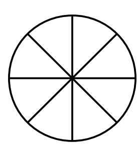
6. You are given with a box of geometrical shapes. Design a public place of your choice and name it. There is no restriction in the numbers that you can use a shape.

(8 minutes)



Eg:

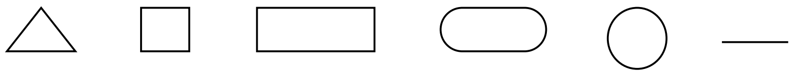
7. Using lines and parts of circle draw patterns (Passing through a single point.) There is no restriction in number that you can use.

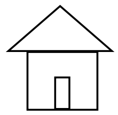


(5 minutes)

Eg. Wheel

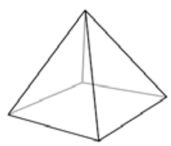
8. Design various things using the following shapes (not necessarily all of them) and name them.





Eg: House (5 minutes)

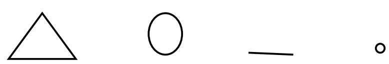
9. Using match sticks form meaningful patterns. Draw as many figures involving triangles and name them



. (5 minutes)

Eg. Pyramid

10. Using the figures given below, design faces. Also name them.



Eg. Cat face (8 minutes)

Appendix D

MATHEMATICAL CREATIVITY POST-TEST (DRAFT)

Standard: 5, 6, 7 Time: 60 minutes

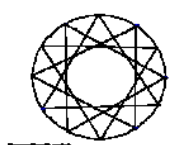
Instructions for all the questions you can give as many responses as you can. Also try to name or describe the use of the item in your own words. Please ensure your response for each question. Your responses will be used for research purpose only.

---

1. You are given with nine sticks of varying length. Design as many patterns as possible. Also name them. (7 minutes)

Eg: Shape of a hut

2. Form as many meaningful shapes using triangles of any size. Also name them. (7 minutes)



Eg: Pookkalam

3. Using geometrical shapes draw animal pictures of your choice and mark the geometrical shapes included in it. (Try to include different types of geometrical shapes). (5 minutes)

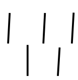
Eg: Bear

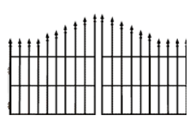
4. Demolish the given house and using the shapes availed reconstruct an entirely new entity. (5 minutes)

5. Using squares of any size design as many furniture you can

Eg: Table . (6 minutes)

6. Expand the given incomplete figure into a meaningful entity.



Eg: Gate  (7 minutes)

7. Using a semi-circle and rhombus as compulsory components, design various objects and name them.

Eg: Table lamb (5 minutes)

8. Using three dimensional figures like cube, cuboid, sphere etc. form as many objects as possible. Name and describe their uses.(5 minutes)

Eg: Setty

9. Using different geometrical shapes draw as many household articles as possible. (7 minutes)

Eg: Clock 

10. Using circles and parts of circle design as many objects as possible. (6 minutes)

Eg. Jug 

Appendix E

MATHEMATICAL CREATIVITY PRE-TEST (FINAL)

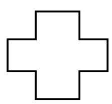
Standard: 5, 6, 7 Time: 40 minutes

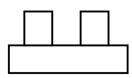
Instructions for all the questions you can give as many responses as you can. Also try to name or describe the use of the item in your own words. Please ensure your response for each question. Your responses will be used for research purpose only.

---

1. Construct different meaningful figures using the cut pieces formed by cutting the figure with only two straight lines. Also name them.

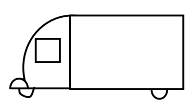
   (7 minutes)





Eg: Setty

2. Using different geometrical shapes draw a vehicle of your choice and mark the geometrical shapes included in it. (Try to include different types of geometrical shapes). (7 minutes)



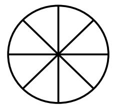
Eg: Autorikshaw

3. You are given with a box of geometrical shapes. Design a public place of your choice and name it. There is no restriction in the numbers that you can use a shape. (8 minutes)

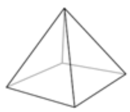
Eg:

4. Using lines and parts of circle draw as many patterns (passing through a single point.) There is no restriction in number that you can use.

(5 minutes)

Eg. Wheel 

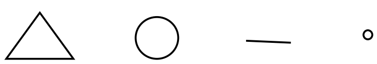
5. Using match sticks form meaningful patterns. Draw as many figures involving triangles and name them

 . (5 minutes)

Eg. Pyramid

6. Using the figures given below, design faces. Also name them.

(8 minutes)



Eg. Cat face

Appendix F

MATHEMATICAL CREATIVITY POST-TEST (FINAL)

Standard: 5, 6, 7 Time: 40 minutes

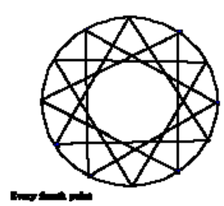
Instructions for all the questions you can give as many responses as you can. Also try to name or describe the use of the item in your own words. Please ensure your response for each question. Your responses will be used for research purpose only.

---

1. You are given with nine sticks of varying length. Design as many patterns as possible. Also name them.

Eg: Shape of a hut (7 minutes)

2. Form as many meaningful shapes using triangles of any size. Also name them. (7 minutes)



Eg: Pookkalam

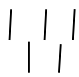
3. Using squares of any size design as many furniture you can.

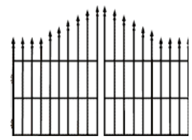
(6 minutes)

Eg: Table

4. Expand the given incomplete figure into a meaningful entity.

(7 minutes)



Eg. Gate 

5. Using different geometrical shapes draw as many household articles as possible. (7 minutes)

Eg: Clock 

6. Using circles and parts of circle design as many objects as possible.

(6 minutes)

Eg. Jug 

Scoring of Mathematical Creativity

There are four components fluency, flexibility, originality and elaboration in each of the ten items. Aggregate score for a single item is the sum total of the scores for the above four components. Total score of the learner in the pre test on mathematical creativity (pilot study) is the sum total of scores in all the ten items.

Components	**Specifications**	**Scoring**	
Fluency	Number of relevant, rational responses	1 score for each correct answer	
Flexibility	Number of relevant categories	1 score for each category	
Originality	Uncommonness	<5%	5 marks
		5-10%	4 marks
		10-15%	3 marks
		15-20%	2 marks
		20-25%	1 mark
		>25%	0 marks
Elaboration	Number of responses meaningfully developed	1 score for each relevant and meaningful responses	

Appendix G

MODULE-I

BASIC GEOMETRIC CONCEPTS

Submodule-1	Point, Line and Plane
Submodule-2	Line, Ray and Line Segment
Submodule-3	Plane and Curved Surfaces

SUBMODULE-1

POINT, LINE AND PLANE

OBJECTIVES

1. To make the learner know about point, line and plane.
2. To enable the learner understand the relation of point with line and plane.
3. To enable the learner apply the knowledge of points, line and plane in solving puzzles.
4. To analyze situations where the concepts of points, line and plane are involved.
5. To judge the appropriateness of using points, lines and planes at particular situations.
6. To develop creative responses for activities involving points, lines and planes.

CONTENT

POINT

A point is the basic unit of Geometry. A point is that which has no parts. It shows an exact location. It is almost invisible tiny point.

LINE

A line is length without breadth. A line is a collection of points going endlessly in both directions along a straight path. A Line is endless. For practical purpose we limit the length and denote it as

←-------------→

and name it X←-------------→Y, Line XY.

PLANE

Infinite number of lines constitutes the plane. Plane has length and breadth, but no thickness.

CONCLUSION

Thus a plane is the union of infinite number of lines and a line is the union of infinite -number of points.

PRESENTATION DESCRIPTION

Visual

Power point presentation on a point and its illustration is shown.

Auditory

A point! It is the basic unit of geometry. It has no parts, breadth or length. It determines the exact location in space. We represent a point using a capital letter. Here 'A' is a point.

Visual

Picture of a point formed by a compass is shown.

Example for a point

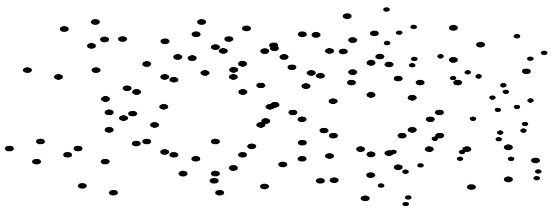
Auditory

When we draw a circle using a compass, the centre made by it is an example for point.

Visual

Picture of scattered points is shown.

Scattered Points

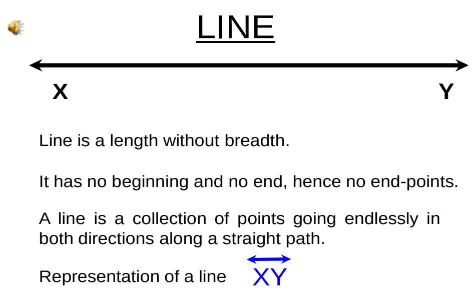


Auditory

Scattered points! Here the points are scattered in the plane.

Visual

Picture of a line is shown.



Auditory

Line is a length without breadth.It has no beginning and no end, hence no end-points. A line is a collection of points going endlessly in both directions along a straight path.Representation of a line is given.

Visual

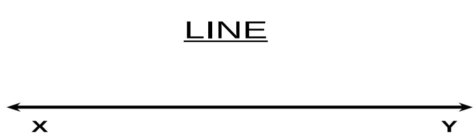
Animation of points in a straight path to form a line is shown

Auditory

Now, many points join together in a straight path to form a line. Line is endless; that is a length without breadth. It extends indefinitely in both directions.

Visual

Picture of representing a line is shown.

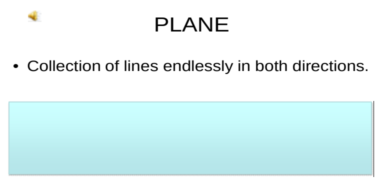


Auditory

A line is expressed as shown and is read as line XY.

Visual

Picture of a plane is shown



Auditory

A collection of lines endlessly in both directions form a line.

Visual

Animation of forming a plane with lines is shown.

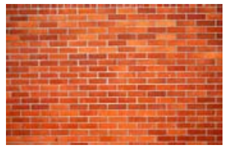
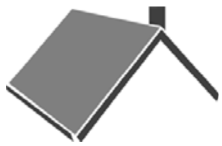
Auditory

Infinite number of lines constitutes a plane. Plane has length and breadth, but no thickness. A plane is a flat surface. It cannot be drawn on a piece of paper since it has no boundary. What we draw on a paper is only a part of a plane but not the plane itself.

Visual

Pictures Illustrating planes are shown.

Examples

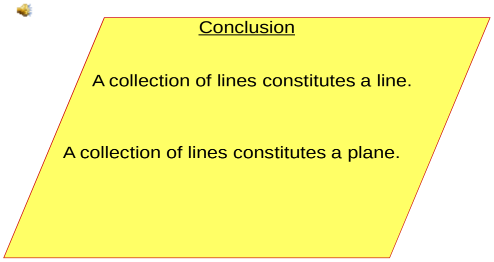




Auditory

Some examples for part of the plane are table top, the side of a wall, roof of the room etc.

Visual

Conclusion of the sub-module is given.



Auditory

Thus, we can conclude that a plane is the collection of lines which is a collection of points along a straight path.

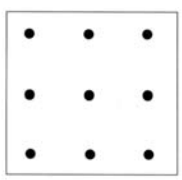
ACTIVITY

Each student is given with a card with marked points arranged in rows and columns at a distance 1 cm each. Students are asked to join the given points for making various figures and name them each.

Eg:

PUZZLE

Connect all the nine dots using only four straight lines at a stretch (without taking pen from the paper).



HOME ASSIGNMENT

Using a maximum of ten points, draw various patterns. Identify them with objects around you. Explain.

Eg: Star

SUBMODULE-2

LINE, RAY AND LINE SEGMENT

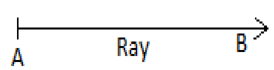
OBJECTIVE

1. To enable the learner know about line-segment, ray and line.
2. To enable the learner understand the relation of line-segment, ray and line.
3. To enable the learner apply the knowledge of line-segment, ray and line in solving puzzles.
4. To analyze situations where the concepts of line-segment, ray and line can be used.
5. To judge the appropriateness of using line-segment, ray and line at particular situations.
6. To develop creative responses for activities involving line-segment, ray and line.

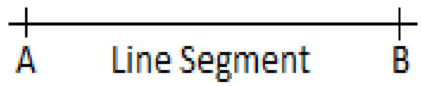
CONTENT

RAY

A ray is a part of a line, which has one end point. It extends endlessly in one direction.



LINE SEGMENT

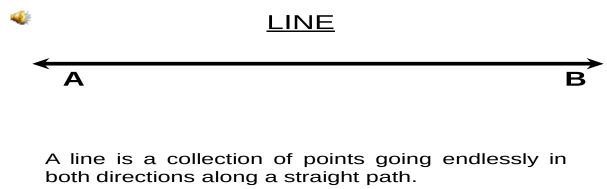


Line segment is a part of a line, which has two end points

<u>PRESENTATION DESCRIPTION</u>

Visual

Picture of a line is shown.

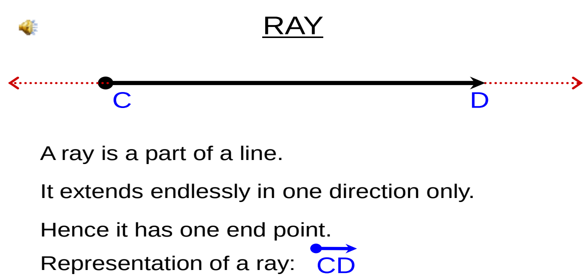


Auditory

A line is a collection of points going endlessly in both directions along a straight path. Here AB is a line.

Visual

Picture of a ray is shown.

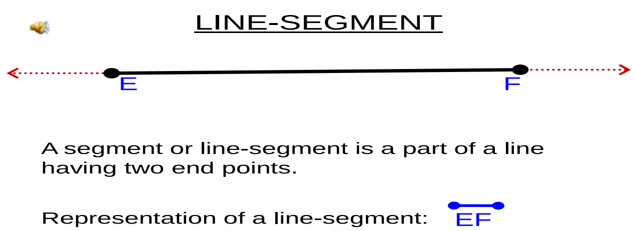


Auditory

A ray is a part of a line.It extends endlessly in one direction only.Hence it has one end point.Representation of a ray is given. Here CD is a ray.

Visual

Picture of a line-segment is shown.

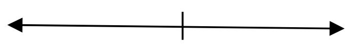


Auditory

A segment or line-segment is a part of a line having two end points. Representation of a line-segment is given. Here EF is the line-segment.

Visual

Animation of a line becoming a ray is shown.



Auditory

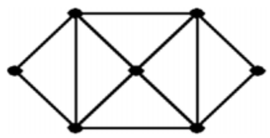
Part of a line is cut apart and becomes a ray. That is, ray a portion of a line. It starts from a point and goes endlessly in one direction. Part of a ray is cut apart and becoming a line-segment. That is, a line-segment is also a part of a line which has two end points.

<u>ACTIVITY</u>

In this activity, line-segments are made without using scale. The items needed for this activity are a paper and colour pen. Fold the given paper to form line-segments and mark them us colour pen. Make as many such line-segments as possible.

PUZZLE

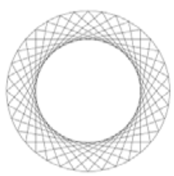
Draw the following figure using line-segments without taking pen from the paper. But the line-segments should not cross each other or over ride anywhere.



HOME ASSIGNMENT

Make as many curve-like patterns using straight lines.

Eg:



SUBMODULE-3

PLANE AND CURVED SURFACES

OBJECTIVES

1. To make the learner know about plane and curved surfaces.
2. To understand the features of plane and curved surfaces.
3. To enable the learner apply the concepts of plane and curved surfaces in solving puzzles.
4. To analyze situations where the concepts of plane and curved surfaces are involved.
5. To judge the appropriateness of using plane and curved surfaces at particular situations.
6. To develop creative responses for activities related to plane and curved surfaces.

CONTENT

SURFACES

In geometry we term the faces of any object as surfaces. There are two kinds of surfaces.

1. PLANE SURFACE

Plane or flat face of an object is called a plane surface. The surface of paper, top of a table or box etc. are examples for plane surfaces.

2. CURVED SURFACE

Spherical or unplained surface of an object is called a curved surface. The surface of a football, cricket ball, round bottle, orange, grapes, mango etc. are examples for curved surfaces.

PRESENTATION DESCRIPTION

Direct experience on plane and curved surfaces.

The teacher demonstrates plane and curved surfaces by showing examples from surroundings. Each of the students is given with plane and curved surfaces. They are asked to draw curves and straight lines on the surface. They are asked to explain the observed difference between two types of surfaces (given to them).

Visual

Types of surfaces are explained.

Auditory

In geometry the faces of any object are called surfaces. There are two kinds of surfaces viz., plane surface and curved surface.

Visual

Plane surfaces are explained.

Auditory

Plane or flat face of an object is called a plane surface.

Visual

Plane surfaces are illustrated with pictures.

Examples for Plane Surfaces

Auditory

Some examples for plane surfaces are black board, table-top, laptop and tennis court.

Visual

Curved surfaces are explained.

CURVED SURFACE

- Spherical or unplained surface of an object is called a curved surface.

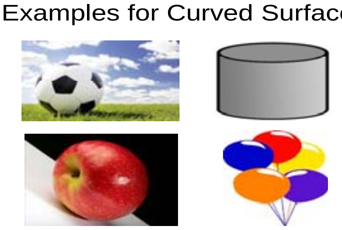
Auditory

Spherical or unplained surface of an object is called a curved surface.

Visual

Curved surfaces are illustrated with pictures.

Examples for Curved Surfaces



Auditory

Some examples for curved surfaces are football, vessels, apple and balloons.

ACTIVITY

Identify the surfaces where straight lines and curves can be drawn and surfaces where only curves can be drawn. The teacher shows some objects two at a time and asks the students to differentiate them (with their properties)

a. a foot ball and a piece of card board

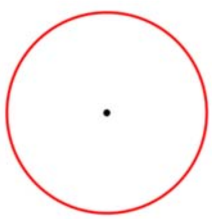
b. a sea shell and a slate

c. a pot and a writing pad

d. an egg shell and a note book

PUZZLE

Without taking pen from the paper draw a circle and a point at its centre.

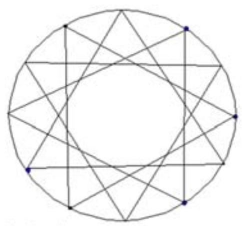


HOME ASSIGNMENT

Make a list of plane and curved surfaces from your surroundings.

MODULE TEST-I

1. Draw as many patterns as you can with the theme, 'From a point as centre' and name the figures you have drawn.



Every fourth point

2. Find examples from your surroundings for point, line, line-segment, ray etc.

Point: bindi

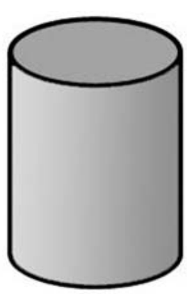
Line: railway line

Line-segment: edge of a scale

Ray: beam of a torch light

3. Draw a theme based figure and mark all the shapes you know with special emphasis on plane and curved surface.

Eg:



MODULE II

ANGLES

Submodule-1	The concept of angles and its measurement
Submodule-2	A pair of straight lines and angles between them

SUBMODULE – 1

THE CONCEPT OF ANGLES AND ITS MEASUREMENT

OBJECTIVES

1. To make the learner know about angles, their measurements and types of angles.
2. To enable the learner understand various characteristics of angles, their measurements and types of angles.
3. To analyze the situations where the concept of angles are involved.
4. To judge the appropriateness of using various types of angles.
5. To develop creative responses for activities related to angles and their measurements.

CONTENT

ANGLE

An angle is a collection of points that is the union of two rays having same end point.

For example, hands of a clock, two arms of a divider, and two sharp edges of a scissors are all hinged at a point and thus are inclined to each other. This inclination between two arms is known as angle.

ARMS OF AN ANGLE

Arms are the sides of an angle that is the rays by which an angle is formed.

VERTEX OF AN ANGLE

Vertex of an angle is the common point where the two rays meet.

MEASUREMENT OF ANGLES

The measurement of angles is performed using a protractor.

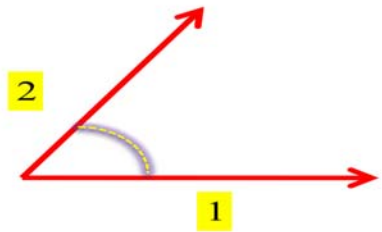
TYPES OF ANGLES

1	Right Angle	An angle whose measure is 90°
2	Acute Angle	An angle whose measure is less than 90°
3	Obtuse Angle	An angle whose measure is greater than 90° but less than 180°
4	Straight Angle	An angle whose measure is 180°
5	Reflex Angle	An angle whose measure is more than 180° but less than 360°

PRESENTATION DESCRIPTION

Visual

Animation of rays forming an angle between them is shown.

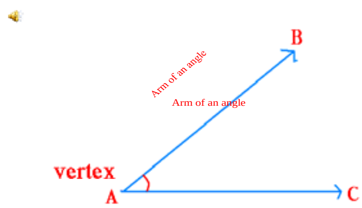


Auditory

Ray 1, ……………..Ray 2, ………………. They form an angle. That is, an angle is formed at the corner where two rays intersect.

Visual

A picture showing parts of an angle such as vertex and arms of the angle.



Auditory

Otherwise, rays can be named like AB, AC etc. Here two rays AB and AC have a common end point A. So they form an angle BAC. The common end point is called the Vertex, here A is the vertex and rays AB and AC are the arms of the angle.

Visual

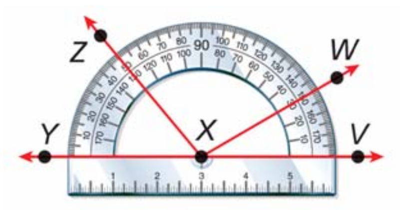
Picture of a pen and its shadow is shown for illustrating formation of an angle.

Auditory

In this picture the pen and its shadow forms an angle.

Visual

The measurement of angles using a protractor is demonstrated.

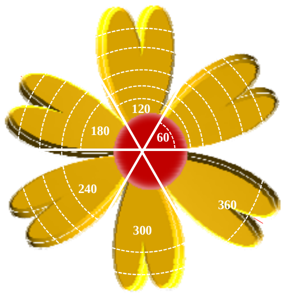


Auditory

Now, let us measure the angles using a protractor. Place the center of the protractor at the vertex of the angle; say X. Align one side of the angle with the base of the protractor so that the other side of the angle intersects the curved edge of the protractor. Now, use the scale starting at O and read the measure of the angle where the other side of the angle intersects the curved edge of the protractor.

Visual

Animation of measuring an angle, using the picture of a six petal flower is shown.

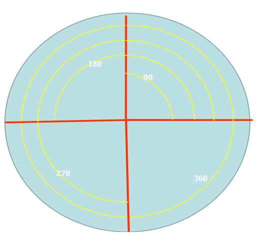


Auditory

Here we have a flower with six petals! Shall we measure the angles of petals? The angle measure of first petal is 60°, the second is 120°, the third is 180°, fourth is 240°, fifth is 300° and when we complete with the last petal one circle is completed and the angle measures 360°.

Visual

Animation of measuring the angles inside a circle is shown.



Auditory

Here we demonstrate the angular measurement of a circle. The circle is divided into four equal parts and each quadrant measures 90°. The angle measure of a half circle is 180°, three fourth of the circle measures 270° and a full circle measures 360°.

Visual

Types of angles are explained here.

Auditory

Now, let us see some types of angles which are categorized according to their angular measures.

Visual

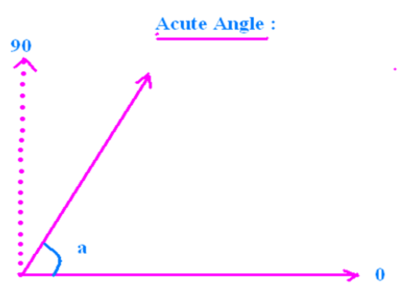
Power point presentation of right angle is shown.

Auditory

An angle whose measure is 90° is called right angle.

Visual

Power point presentation of acute angle is shown.

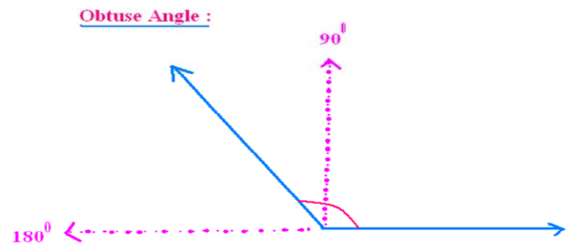


Auditory

An angle whose measure is less than 90° is called an acute angle.

Visual

Power point presentation of obtuse angle is shown.

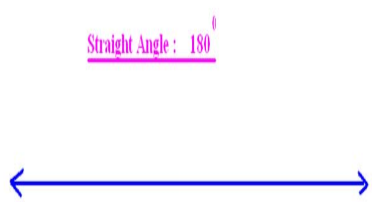


Auditory

An angle whose measure is greater than 90° but less than 180° is called an obtuse angle.

Visual

Power point presentation of straight angle is shown.

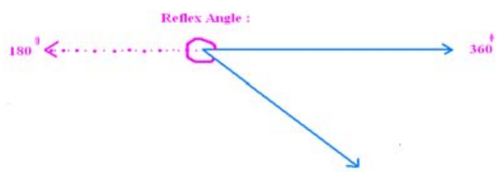


Auditory

An angle whose measure is 180° is called a straight angle.

Visual

Power point presentation of reflex angle is shown.



Auditory

An angle whose measure is more than 180° but less than 360° is called a reflex angle.

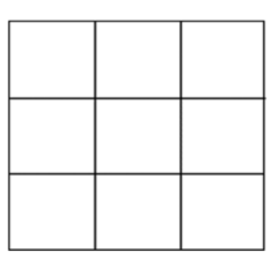
<u>ACTIVITY</u>

Draw a star on the space below and mark all the possible angles with a colour pencil. Also measure each of them using a protractor.

Eg. 

<u>PUZZLE</u>

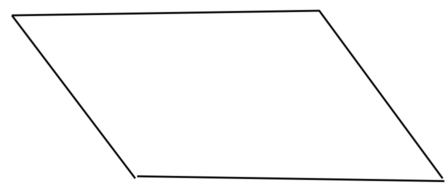
In the following figure 24 sticks form 9 squares. Remove eight sticks and form exactly four equal squares.



HOME ASSIGNMENT

Using four straight lines, how many angles can be formed? Demonstrate as many types of arrangements as possible.

Eg: Four angles



SUBMODULE-2

PAIR OF STRAIGHT LINES AND ANGLES

OBJECTIVES

1. To make the learner know about pair of straight lines and angles between them.
2. To enable the learner understand various angles formed between pair of straight lines.
3. To analyze the situations where the concept of pair of straight lines and angles between them concepts can be used.
4. To judge the appropriateness of using angles formed between pair of straight lines at particular situations.
5. To develop creative responses for activities related to the concept of pair of straight lines and angles between them.

CONTENT

The two lines can be

1.	Coincident	If a line lies exactly on the other, we say the lines are coincident
2.	Parallel	Two lines are said to be parallel if they do not intersect each other at any point even if extended to infinity
3.	Intersecting	If two lines meet at any point, we say they are intersecting
4.	Perpendicular	Two lines are said to be perpendicular to each other if one of the angles formed by them is a right angle

PAIR OF ANGLES

1	Supplementary Angles	Two angles whose sum is 180° are called supplementary angles and one is called the supplement of the other.
2	Linear Pair	Two adjacent angles are said to form a linear pair if their sum is 180°.
3	Complementary Angles	Two angles whose sum is 90° are called complementary angles and one is called the complement of the other.
4	Vertically Opposite Angles	When two lines intersect, four angles are formed. Each opposite pair is called vertical angles and is always congruent.
5	Adjacent Angles	Two angles having a common vertex and a common side are called adjacent angles.
6	Corresponding Angles	Two angles which occupy the same relative position at each intersection where a straight line crosses two others. If the two lines are parallel, the corresponding angles are equal.
7	Co-Interior Angles	Two lines are co-interior if they are interior angles lying on the same side of the transversal. If the lines are parallel the co-interior angles are supplementary.
8	Co-exterior Angles	Two lines are co-exterior if they are exterior angles lying on the same side of the transversal. If the lines are parallel the co-exterior angles are supplementary.
9	Alternate-Interior Angles	Pair of angles on opposite sides of the transversal but inside the two lines are called Alternate Interior Angles.

PRESENTATION DESCRIPTION

Visual

The relationship between two lines is explained.

RELATIONSHIP BETWEEN TWO LINES

- Coincidental
- Parallel
- Intersecting
- perpendicular

Auditory

The relationship between two lines can be coincident, parallel, intersecting or perpendicular.

Visual

Picture of a pair of coincidental lines are shown.

Auditory

If a line lies exactly on the other, we say the lines are coincident.

Visual

Picture of a pair of parallel lines are shown.

Auditory

Two lines are said to be parallel if they do not intersect each other at any point even if extended to infinity.

Visual

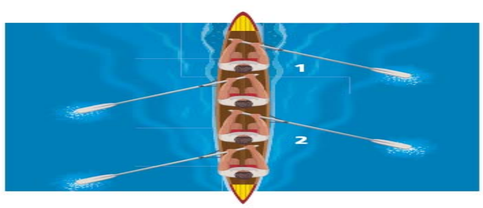
The picture of a railway track is shown for illustrating parallel lines.

Auditory

Opposite tracks of a railway are said to be parallel.

Visual

The picture of a boat and rows is shown for illustrating parallel lines.



Auditory

Here in this picture, the roars are placed parallel.

Visual

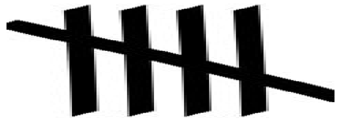
Picture of a pair of intersecting lines are shown.

Auditory

If two lines meet at any point, we can say that they are intersecting.

Visual

The picture of a gate is shown for illustrating intersecting lines.

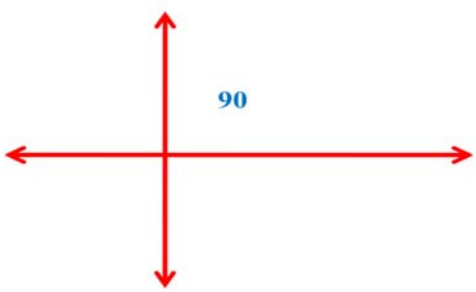


Auditory

Here, the gate or fence having an intersecting lines pattern.

Visual

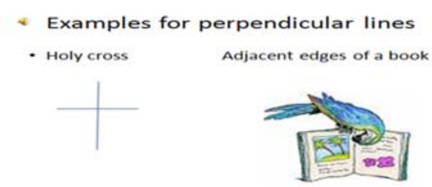
Picture of a pair of perpendicular lines are shown.



Two lines are said to be perpendicular to each other if one of the angles formed by them is a right angle.

Visual

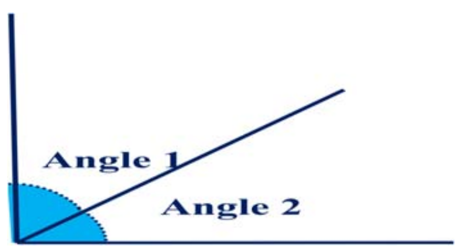
The picture of a holy cross and a book are shown for illustrating perpendicular lines.



Adjacent edges of a holy cross, adjacent edges of a book etc. are examples for perpendicular lines.

Visual

Picture is shown for illustrating complementary angles.

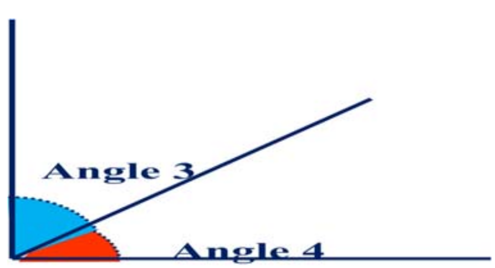


Auditory

Two angles whose sum is 90° are called complementary angles and one is called the complement of the other. Here, angle 1 and angle 2 sums up to 90°. Hence one is the complement of the other.

Visual

Picture is shown for illustrating non-complementary angles.

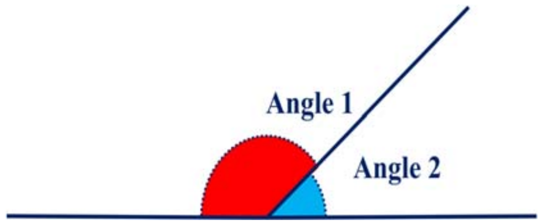


Auditory

Sum of angles 3 and 4 is more than 60°. So they are not complementary angles.

Visual

Picture is shown for illustrating supplementary angles.

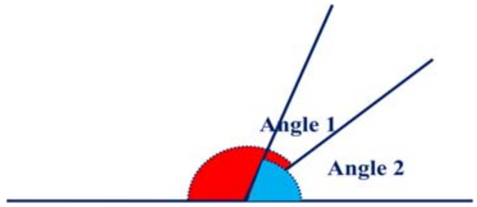


Auditory

Two angles whose sum is 180° are called supplementary angles and one is called the supplement of the other. Here, angle 1 and angle 2 sums up to 180°. Hence they are supplement to each other.

Visual

Picture is shown for illustrating non-supplementary angles.

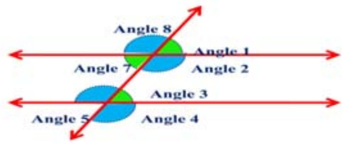


Auditory

Angles 1 and 2 are placed along a line one after the other in such a way that they have a common ray. They fit exactly on a line hence together making an angle 180°. Then they are called a linear pair.

Visual

Two parallel lines and a transversal are shown.

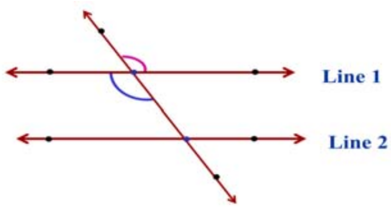


Auditory

Here two parallel lines are cut by a transversal and the angles formed are angle 1, angle 2, angle 3, angle 4, angle 5, angle 6, angle 7 and angle 8.

Visual

Animation is shown by highlighting angles 1 and 7 to demonstrate 'vertically opposite angles'.

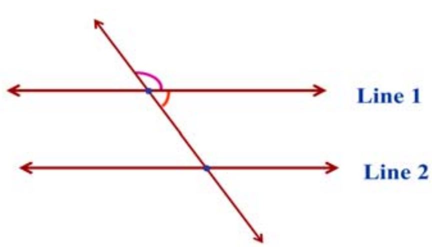


Auditory

Each opposite pair of angles is called vertically opposite angles and they are always equal. Here angle 1 and angle 7 are equal`.

Visual

Animation is shown by highlighting angles 1 and 2 to demonstrate 'adjacent angles'.

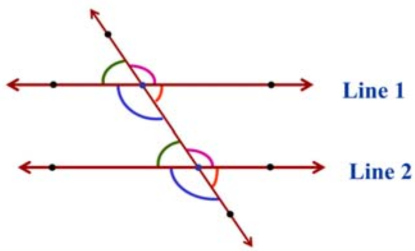


Auditory

Two angles having a common vertex and a common side are called adjacent angles and are always supplementary. Here angle 1 and angle 2 is a pair ofadjacent angles.

Visual

Animation is shown by highlighting angles 1 and 3 to demonstrate ‘corresponding angles’.

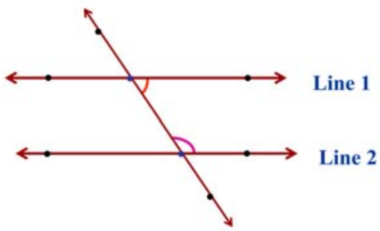


Auditory

Two angles which occupy the same relative position at each intersection where a straight line crosses them are called corresponding angles and they are always equal. The corresponding angles are equal. Here angle 1 and angle 3 is a pair ofcorresponding angles.

Visual

Animation is shown by highlighting angles 2 and 3 to demonstrate ‘co-interior angles’.

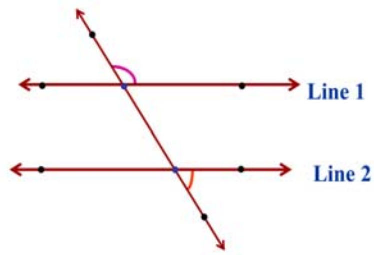


Auditory

Two lines are co-interior if they are interior angles lying on the same side of the transversal. Since the lines are parallel, the co-interior angles are supplementary. Here angle 2 and angle 3 is a pair of co-interior angles.

Visual

Animation is shown by highlighting angles 1 and 4 to demonstrate 'co-exterior angles'.

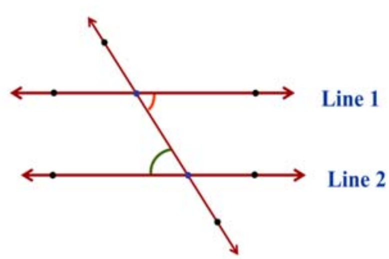


Auditory

Two lines are co-exterior if they are exterior angles lying on the same side of the transversal. Since the lines are parallel, the co-exterior angles are supplementary. Here angle 1 and angle 4 is a pair of co-exterior angles.

Visual

Animation is shown by highlighting angles 2 and 6 to demonstrate 'alternate-interior angles'.

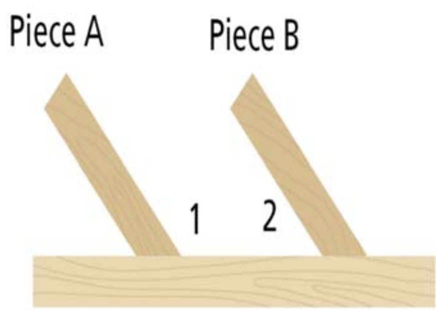


Auditory

The pair of angles on opposite sides of the transversal but inside the two lines are called alternate interior angles. Here angle 2 and angle 6 is a pair of alternate interior angles.

Visual

Picture of a carpentry application is shown.



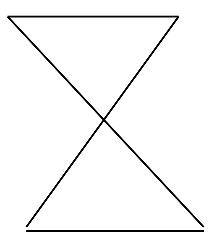
Auditory

Here we have an example of carpentry application for two parallel lines are cut by a transversal. Now try to find all the angles associated with it.

<u>ACTIVITY</u>

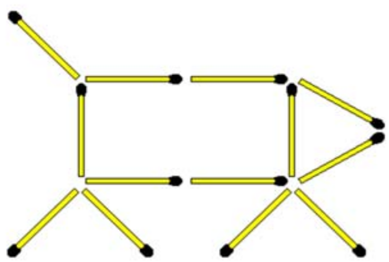
Draw a theme based picture and identify parallel and perpendicular lines in it.

Eg: Drum



PUZZLE

Can you change the direction of the pig using only three moves?



HOME ASSIGNMENT

Stuff various types of flowers in your book and measure the angles after it get dried.

EXTRA ACTIVITIES

1. Find examples from surroundings for parallel, perpendicular and intersecting lines.

2. Make angles by folding the paper and mark them using colour pencils. Can you find the angle measures without any tools? Verify the measure with a protractor.

3. Observe various instances of angle formations at your home.

MODULE TEST-II

1. Draw and explain as many angles involved in alphabets.
2. Name as many articles involving parallel and perpendicular lines.

   Eg: Book shelf has both parallel and perpendicular lines

3. Mark and name all the possible angles on the figure of the tree below.

MODULE III

POLYGONS

Sub module : 1	Curves
Sub module : 2	Types of polygons and their characteristics

SUB MODULE – 1

CURVES

OBJECTIVES

1. To make the learner familiar with curves and its types.
2. To enable the learner distinguish between simple and complex curves.
3. To enable the learner distinguish between open and closed curves.
4. To enable the learner locate various types of curves in his/her surroundings.
5. To enable the learner think creatively on the knowledge of curves.

CONTENT

Curves

The doodling on a paper are examples of curves, which are not straight. Curves that do not cross itself are called simple curves and otherwise called non-simple or complex curves.

- ➢ Open curves are curves having distinct starting and end points.
- ➢ Closed curves have no distinct end points.

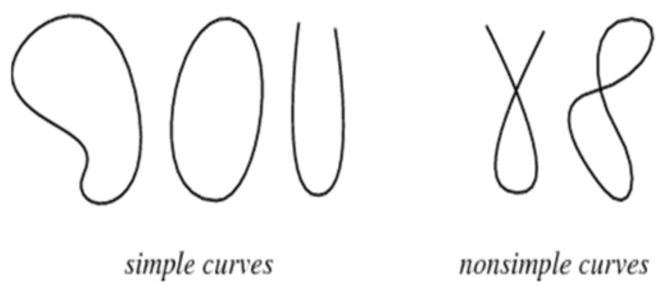
Parts of a Curve

1. Interior
2. Exterior
3. Boundary

PRESENTATION DESCRIPTION

Visual

Examples for simple and non-simple (complex) curves are shown.

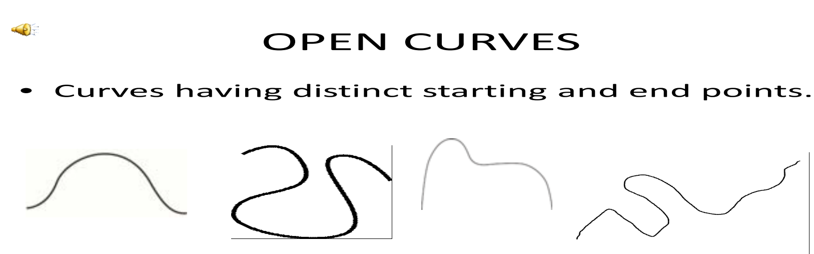


Auditory

Curves! Curves that do not cross itself are called simple curves; otherwise non-simple or complex curves. Let us see some examples for simple and complex curves.

Visual

Picture of open curves are shown.

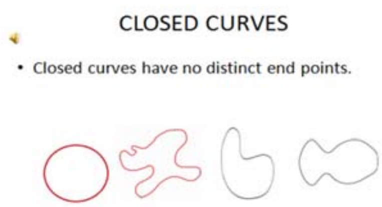


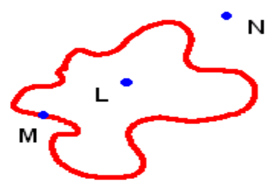
Auditory

Open curves! Curves having distinct starting and end points are called open curves.

Visual

Picture of closed curves are shown. Also interior, exterior and boundary of a curve are illustrated using a picture.



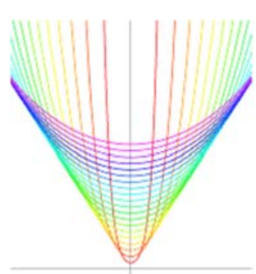


Auditory

Closed curves! Closed curves have no distinct starting and end points. Pictures of closed curves are shown. Here ‘L’ is an interior point, ‘N’ is an exterior point and ‘M’ is a point on the boundary of the curve.

<u>ACTIVITY</u>

The teacher asks students to make various types of curves using coloured threads in a paper.



JIGSAW PUZZLE

Students are given the game of jigsaw puzzle.


HOME ASSIGNMENT

Identify objects with curves from your environment.

Eg: 

SUBMODULE - 2

TYPES OF POLYGON AND THEIR CHARACTERISTICS

OBJECTIVES

1. To make the learner know about polygons.
2. To enable the learner compare the properties of various polygons.
3. To enable the learner apply polygons at particular situations.
4. To analyze situations where polygons are involved.
5. To judge the appropriateness of the above mentioned concepts at particular situations.
6. To enable the learner use various polygons creatively.

CONTENT

Polygon

Closed figures made up entirely of line-segments are known as polygons.

Properties of a Polygon

Sides, vertices and diagonals are called the elements of a polygon. Vertices are angular points where two line-segments meet. Sides of a polygon are obtained by joining the adjacent vertices. Diagonals of a polygon are obtained by joining the vertices which are not adjacent.

Types of Polygons

Type of Polygon	**No. of vertices**	**No. of sides**	**No. of angles**	**No. of diagonals from a common vertex**	**Total no. of diagonals**
Triangle	3	3	3	0	0
Quadrilateral	4	4	4	1	2
Pentagon	5	5	5	3	5
Hexagon	6	6	6	3	9
Heptagon	7	7	7	4	14
Octagon	8	8	8	5	20
	N	n	n	n-3	n (n-3)/2

CONCAVE AND CONVEX POLYGONS

A polygon is concave if part of any diagonal contains points in the exterior of the polygon. If no diagonal contains points in the exterior, then the polygon is convex.

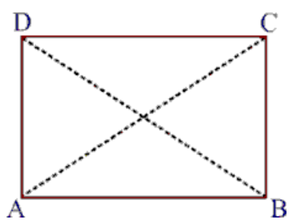
REGULAR AND IRREGULAR POLYGON

A regular polygon is one that is both equilateral (all the sides are congruent) and equiangular (all angles are congruent). If a polygon is not regular it is called irregular.

PRESENTATION DESCRIPTION

Visual

Picture of a polygon is shown for describing about polygons.

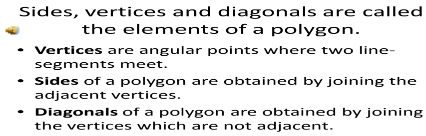


Auditory

A closed figures made up entirely of line segments are called polygons.

Visual

Elements of a polygon such as vertices, sides, angles and diagonals are explained.


Sides, vertices and diagonals are called the elements of a polygon.

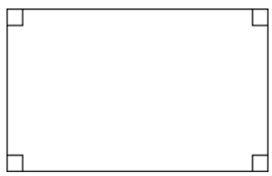
- **Vertices** are angular points where two line-segments meet.
- **Sides** of a polygon are obtained by joining the adjacent vertices.
- **Diagonals** of a polygon are obtained by joining the vertices which are not adjacent.

Auditory

Sides, vertices, angles and diagonals of a polygon are known as the elements of a polygon. Vertices are angular points where two line-segments meet. Sides of a polygon are obtained by joining the adjacent vertices. Diagonals of a polygon are obtained by joining the vertices which are not adjacent.

Visual

Picture of a polygon is shown for describing about the elements of a polygon.



Auditory

Look at this polygon. It is a four sided polygon having four vertices, four sides and four angles. It has two diagonals.

Visual

Picture of a triangle is shown.

Auditory

Now let us see some types of polygons. A triangle! It is the smallest possible polygon. It has three vertices, three sides and three angles; but no diagonals.

Visual

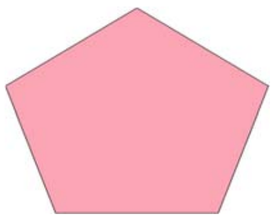
Picture of a quadrilateral is shown.

Auditory

quadrilateral! It is a polygon having four vertices, four sides, four angles and two diagonals. Also the number of diagonals that can be drawn from a common vertex is one.

Visual

Picture of a pentagon is shown.

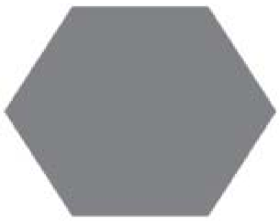


Auditory

Now picture of a Pentagon is shown. It has five vertices, five sides, five angles and five diagonals. The number of diagonals that can be drawn from a common vertex is two.

Visual

Picture of a hexagon is shown.



Auditory

This is a hexagon! A hexagon is a polygon having six sides, six vertices, six angles and nine diagonals. The number of diagonals that can be drawn from a common vertex is three.

Visual

Picture of a heptagon is shown.

Auditory

Heptagon is a polygon having seven vertices, seven sides, seven angles and fourteen diagonals. The number of diagonals that can be drawn from a common vertex is four.

Visual

Picture of a octagon is shown.

Auditory

Octagon is a polygon having eight vertices, eight sides, eight angles and twenty diagonals. The number of diagonals that can be drawn from a common vertex is five.

Visual

A table containing number of sides, vertices, angles and diagonals is shown.

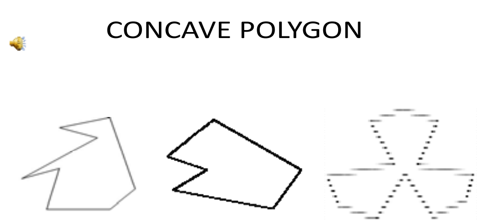
Type of Polygon	**No. of vertices**	**No. of sides**	**No. of angles**	**No. of diagonals from a common vertex**	**Total no. of diagonals**
Triangle	3	3	3	0	0
Quadrilateral	4	4	4	1	2
Pentagon	5	5	5	3	5
Hexagon	6	6	6	3	9
Heptagon	7	7	7	4	14
Octagon	8	8	8	5	20
	N	n	n	n-3	n (n-3)/2

Auditory

From this we can conclude that the number of diagonals that can be drawn in a polygon with ‘n’ sides is ‘n (n-3)/2’. The number of diagonals that can be drawn from a common vertex of a polygon with ‘n’ sides is ‘n-3’. A chart with number of vertices, sides, angles and diagonals of various polygons is shown.

Visual

Pictures concave polygons are shown.

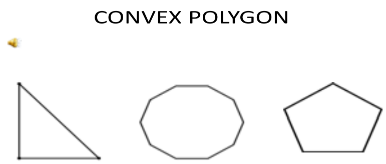


Auditory

Now, look at these polygons! If part of any diagonal of a polygon contains points in the exterior of it, then we call it a concave polygon.

Visual

Pictures of convex polygon are shown.

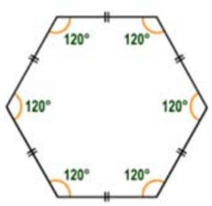


Auditory

If no diagonal contains points in the exterior of a polygon, then the polygon is called convex.

Visual

Pictures of equiangular polygons are shown.

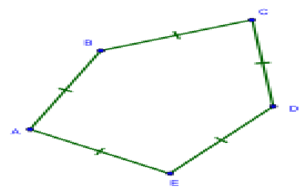


Auditory

If all the angles of a polygon are equal we call it an equiangular polygon.

Visual

Pictures of equilateral polygons are shown.

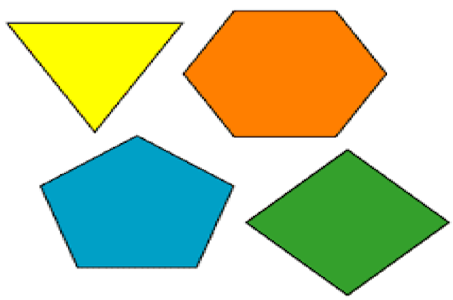


Auditory

If all the sides of a polygon are congruent, we call it an equilateral polygon.

Visual

Pictures of regular polygons are shown.

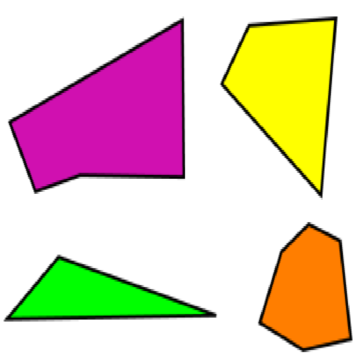


Auditory

A regular polygon is one that is both equilateral and equiangular.

Visual

Pictures of irregular polygons are shown.



Auditory

If a polygon is not regular it is called an irregular polygon.

ACTIVITY

Draw a theme of your choice. Mark all the geometric shapes involved in it.

GAME

A game for two players at a time! They are given two different colours to darken the given bubbles. The players can darken the bubble one after the other in such a way that same colour should not come in adjacent cells. The player who cannot darken the bubble as per the rules is the looser.

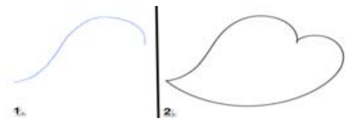
HOME ASSIGNMENT

Using geometrical shapes draw animal pictures.

Eg: 

MODULE TEST-III

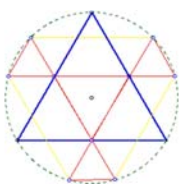
1. Find examples of closed and open curves from surroundings.



2. Select the theme 'children's park' and design it with all the geometric shapes you know. (Use as many shapes as you want).

Eg: 

3. Using a semi-circle and a rhombus as compulsory components, design as many objects.



EXTRA ACTIVITIES

1. Dry various types of leaves by placing it between two pages of a book, in prior. Stick these dried leaves in the place of leaves in the following figure. Make impressions using fresh- cut beetroot in the place of flower. Also draw a plant pot and design it with vegetables. For example cut a lady's finger, dip it in colours and press it in the paper for making designs.

2. Match sticks are given to students to form various polygons.

3. Demolish the house and using the availed shapes and reconstruct an entirely new building.

4. Using the geometric shapes you know, design various electronic gadgets.

5. Four sticks of 4cm, three sticks of 3cm, and three sticks of 2cm are given. Form as many shapes as you can. Name the shape relating it with your daily life articles.

MODULE-IV

CONGRUENCY, SIMILARITY AND SYMMETRY

Sub-module 1	Congruency and Similarity
Sub-module 2	Symmetry

SUBMODULE - 1

CONGRUENCY AND SIMILARITY

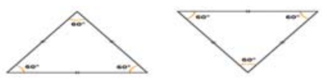
OBJECTIVES

1. To make the learner know about the concept of congruency and similarity.
2. To enable the learner distinguish between congruency and similarity.
3. To compare the properties of congruency and similarity.
4. To enable the learner apply knowledge of congruency and similarity in solving puzzles.
5. To analyze situations where the concepts of congruency and similarity are involved.
6. To judge the appropriateness of the concepts of congruency and similarity at particular situations.
7. To enable the learner deal with the concepts of congruency and similarity creatively.

CONTENT

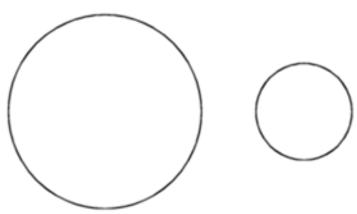
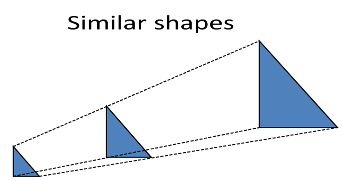
Congruency

If two or more objects have same shape & same size with corresponding lengths and angles, they are congruent. That is, one is the exact copy of the other.

Eg: 

Similarity

Similar objects have same shape but need not be of same size. That is, one is the enlargement of the other.

Eg:  

GAME

The students are divided into groups and the teacher distributes cards of different geometric shapes cut from colored chart papers. The group's task is to cut various geometric figures having the same shape from the colour paper. The group which cuts maximum number of shapes within the stipulated time is declared as the winner and is awarded a token of appreciation.

After the game the teacher helps the students to differentiate the shapes into two categories.

1. Figures having same shape and same size.
2. Figures having same shape but different size.

Discussion

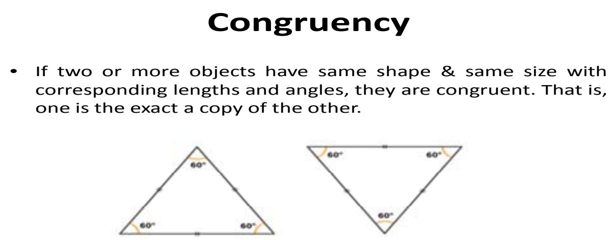
Geometric figures having same shape and same size are called congruent and geometric figures having same shape but different size are called similar. Then various instances of similar and congruent objects are given. The students are asked to judge whether they are similar or congruent. Also find more examples from your surroundings.

1. Bangles in a set
2. Pages of the same book
3. A Jodi of ear studs
4. Plates of a set
5. Tiles paved in a room

<u>PRESENTATION DESCRIPTION</u>

Visual

Congruency is explained with an example.

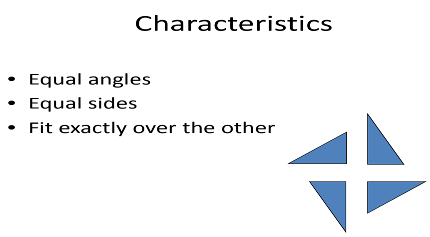


Auditory

If two or more objects have same shape and size with corresponding lengths and angles, they are congruent. That is, one is the exact the copy of the other.

Visual

Characteristics of congruency are explained.

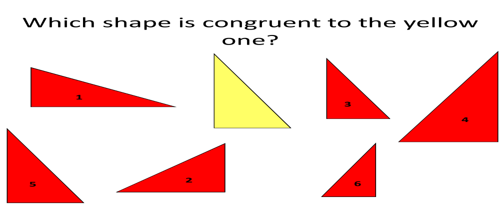


Auditory

If two shapes are congruent they have equal angles, equal sides and fit exactly over the other.

Visual

Demonstration of congruency using an example question is shown.

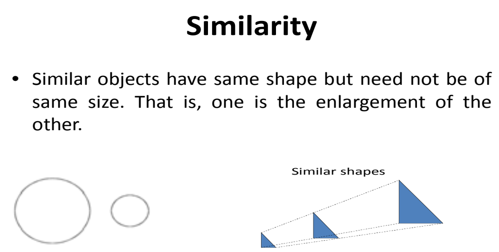


Auditory

Which figure is congruent to the yellow one? Yes, the fifth one.

Visual

Similarity is explained and illustrated with examples.

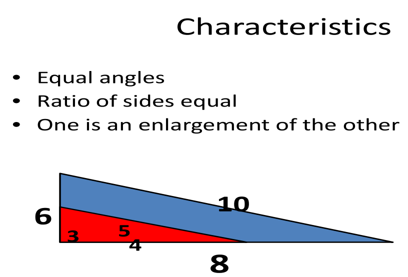


Auditory

Similar objects have same shape but need not be of same size. That is, one is the enlargement of the other.

Visual

Characteristics of similarity are explained.

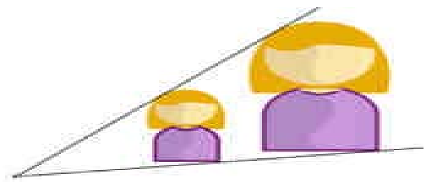


Auditory

If two figures are similar they have equal angles, equal ratio of sides and one is the enlargement of the other.

Visual

Picture for illustrating similarity is shown.

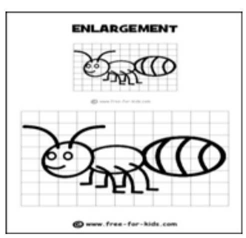


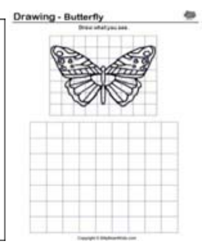
Auditory

These figures have same shape but different size and hence they are similar.

ACTIVITY-1

Picture of a butterfly is given. Enlarge the shape and draw it in the box given as the example of bee.

Eg: 



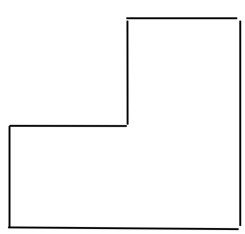
ACTIVITY-2

Find various instances of congruent shapes from your surroundings.

Eg: bangles in a set.

PUZZLE

A farmer has the land holding with the given shape. Divide the land equally among the four sons but with same shape and size.



<u>HOME ASSIGNMENT</u>

Draw similar figures one inside the other as seen below.

Eg: 

<u>SUBMODULE - 2</u>

<u>SYMMETRY</u>

<u>OBJECTIVES</u>

1. To make the learner know about symmetry.
2. To enable the learner identify symmetry in shapes.
3. To enable the learner compare various geometrical shapes for symmetry.
4. To enable the learner distinguish between congruency, similarity and symmetry.
5. To apply the concept of symmetry in solving puzzles.
6. To develop creative responses for activities related to symmetry.

<u>CONTENT</u>

Line of Symmetry

A line through which a pattern can be folded so that both of its sides match is called the line of symmetry. The line of symmetry can be in any direction-vertical, horizontal or diagonal. Here the vertical white line is the line of symmetry.

Symmetry

If we fold a pattern along the line of symmetry, both the sides match through corresponding parts exactly. They are said to be symmetrical.

Types of Symmetry

1. Reflectional symmetry
2. Rotational symmetry

Reflectional Symmetry (Mirror Symmetry)

One half is the reflection or the mirror image of the other, such figures are said to have reflectional symmetry. It is the simplest type of symmetry.

Rotational Symmetry

Even though an image is rotated, it appears the same two or more times; such images are said to have rotational symmetry about its centre. Number of times it appears the same is called its order.

Tessellation

A tessellation (or tiling) is when we cover a surface with a pattern or flat shapes so that there are no overlaps or gaps.

<u>PRESENTATION DESCRIPTION</u>

Visual

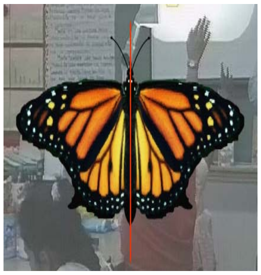
Some figures are shown to explain about symmetry.

Auditory

Symmetry! If two things are said to be symmetric then both of its sides match through corresponding parts exactly.

Visual

Picture of a butterfly is shown to explain about the line of symmetry.

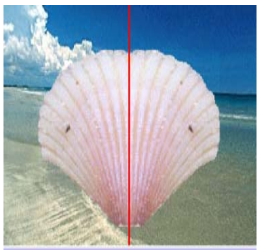


Auditory

For example, a butterfly; if you draw a line down the centre of a butterfly both sides look the same. The line through which a pattern can be folded so that both of its sides match is called the line of symmetry.

Visual

A picture is shown to explain about the vertical line of symmetry.



Auditory

When the line of symmetry goes up and down it is called vertical symmetry. An example for vertical symmetry is given.

Visual

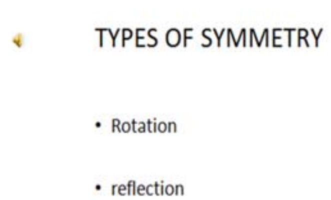
A picture is shown to explain about the horizontal line of symmetry.

Auditory

When the line of symmetry is drawn left to right or across the plane, it is called horizontal symmetry. Examples for horizontal symmetry are shown.

Visual

The types of symmetry are explained.



Auditory

There are two types of symmetry. They are rotational Symmetry and reflectional symmetry.

Visual

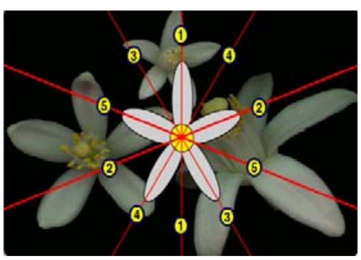
A picture is shown t explain reflectional symmetry.

Auditory

Now, mirror symmetry! One half is the reflection or the mirror image of the other, such figures are said to have reflectional symmetry. It is the simplest type of symmetry.

Visual

A picture is shown t explain rotational symmetry.

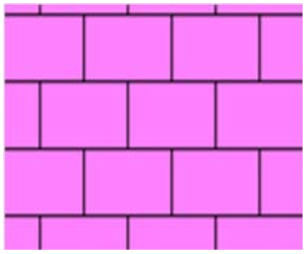


Auditory

Even though an image is rotated, it appears the same two or more times; such images are said to have rotational symmetry about its centre.

Visual

Examples of tessellation are shown.

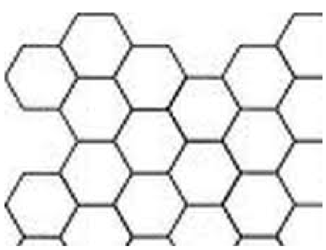
Auditory

Do you know what tessellation is? When we cover a surface with a pattern or flat shapes so that there are no overlaps or gaps, we call it tiling or tessellation. The tiling patterns we see around are examples for tessellation.

ACTIVITY

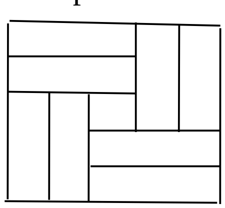
Ask the students to find out various shapes and classify them according to whether they tessellate or not.

Eg:- The tiles of same shape are paved on a floor tessellates



PUZZLE

Set out 20 match sticks in a 5*5 square representing a garden. A centrally positioned 1*1 square represents a well. Divide the garden around the well into 8 symmetrical plots of lands using exactly 20 match sticks. Try it.

Ans: 

Brainstorming Session

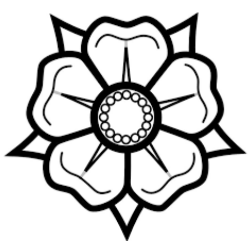
We learned about similar, congruent and symmetric shapes. From the various objects around let us try to identify and differentiate between them.

- Cards from the same deck
- A set of bangles
- A set of plates
- A pair of shoes
- A pair of ear studs

Also the students are asked to give more examples of each category for clarifying the concepts.

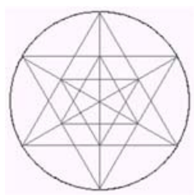
HOME ASSIGNMENT

Draw floral designs on a paper and investigate on figures having ‘multiple lines of symmetry’.



MODULE TEST-IV

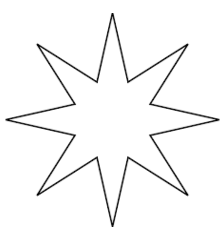
1. Taking the given pattern as 'basic frame rub off some parts of it and make various geometric designs. Identify the design with various objects you are familiar with.



2. Find articles from your surroundings of the following category.

a. Congruent shapes b. Similar shapes

3. Find examples for rotational symmetry from your surroundings.



MODULE V

TRIANGLES

Submodule : 1	Triangle and its properties
Submodule : 2	Triangle-types

SUBMODULE - 1

TRIANGLE AND ITS PROPERTIES

OBJECTIVES

1. To make the learner know about triangles.
2. To enable the learner understand properties of triangles.
3. To enable the learner understand angle sum property of triangles.
4. To enable the learner apply the triangles in solving puzzles.
5. To enable the learner creatively use angle sum property of triangles at particular situations.

CONTENT

TRIANGLE

Triangle is the smallest possible polygon having three sides and three angles. The three angles and the three sides of a triangle are together called the six parts or elements of the triangle.

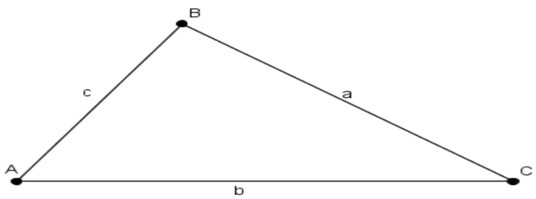
ANGLE SUM PROPERTY

Sum of three angles of a triangle = 180°

PRESENTATION DESCRIPTION

Visual

A picture is shown to explain about of a triangle and its parts.



Auditory

Triangle is the smallest possible polygon having three sides and three angles. Look at the picture. The three vertices A, B, C and three sides a, b, c are marked. Three vertices and three sides are together called the six parts or elements of a triangle.

Visual

Pictures are shown to illustrate triangular objects.

Auditory

Now let us look around and find triangular shaped articles.

Visual

Animation of angle sum property of triangle is shown.

Auditory

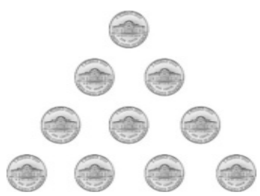
A triangle is drawn and angles are marked as 45°, 90° and 45°. Now let us find the sum of three angles of a triangle. We get the sum as 180°. Hence we have sum of three angles of a triangle is equal to one hundred and eighty degrees.

ACTIVITY

Triangle shaped cards are cut, their corner parts are cut and shuffled. The activity is to find the set of three angles of a triangle by applying the angle-sum property.

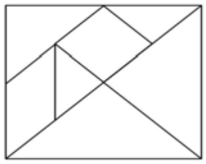
PUZZLE

Ten coins are arranged into a triangular pattern with its peak upwards. Change its peak downwards by moving only three coins.

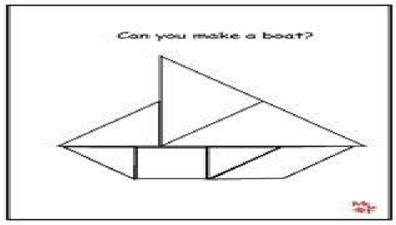


HOME ASSIGNMENT

Join the pieces and make meaningful figures. Also name the articles you have drawn.



Eg:



SUBMODULE - 2

TYPES OF TRIANGLES

OBJECTIVES

1. To make the learner know about various types of triangles.
2. To enable the learner identify types of triangles with their properties.
3. To enable the learner apply knowledge of triangles in solving puzzles.
4. To enable the learner creatively use the concept of triangle at particular situations.

CONTENT

TYPES OF TRIANGLES

1. RIGHT TRIANGLE

A triangle whose one angle is a right angle (that is 90°) is called a right angled triangle or right triangle.

2. OBTUSE TRIANGLE

A triangle having an obtuse angle is called an obtuse angled triangle or obtuse triangle.

3. ACUTE TRIANGLE

A triangle having all the angles are acute is called an acute angled triangle or acute triangle.

4. SCALENE TRIANGLE

A triangle in which all the three sides are unequal in length is called a scalene triangle.

5. ISOSCELES TRIANGLE

A triangle in which two of its sides are equal is called isosceles triangle.

6. RIGHT ANGLED ISOSCELES TRIANGLE

An isosceles triangle whose one angle is 90°is called a right angled isosceles triangle.

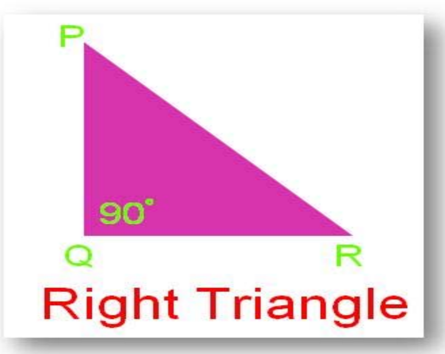
7. EQUILATERAL TRIANGLE

A triangle in which all the three sides are equal in length is called an equilateral triangle.

PRESENTATION DESCRIPTION

Visual

Picture of a right angled triangle is shown.

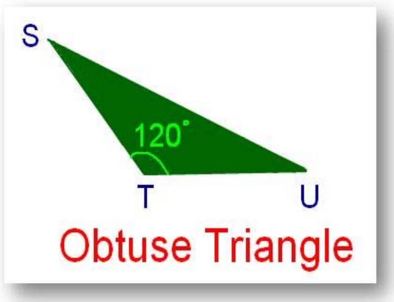


Auditory

Right triangle! A triangle whose one angle is a right angle (that is equal to 90°) is called a right angled triangle or right triangle.

Visual

Picture of an obtuse angled triangle is shown.

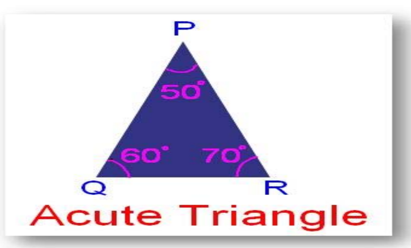


Auditory

Obtuse triangle! A triangle having an obtuse angle (that is greater than 90°) is called an obtuse angled triangle or obtuse triangle.

Visual

Picture of an acute angled triangle is shown.

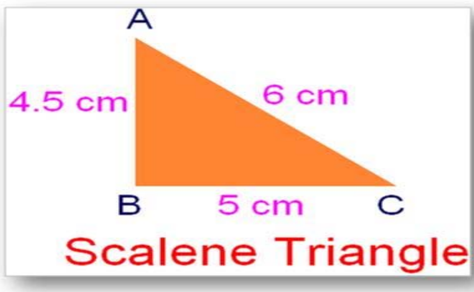


Auditory

Acute triangle! A triangle which has all the three angles are acute (that is less than 90°) is called an acute angled triangle or acute triangle.

Visual

Picture of a scalene triangle is shown.

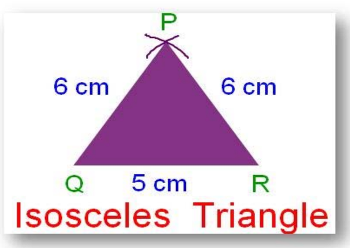


Auditory

Scalene triangle! A triangle in which all the three sides are unequal in length is called a scalene triangle.

Visual

Picture of an isosceles triangle is shown.

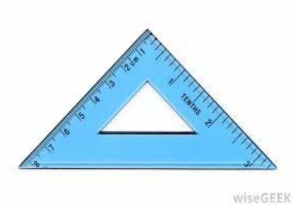


Auditory

Isosceles triangle! A triangle in which two of its sides are equal is called an isosceles triangle.

Visual

Picture of a right angled isosceles triangle is shown.

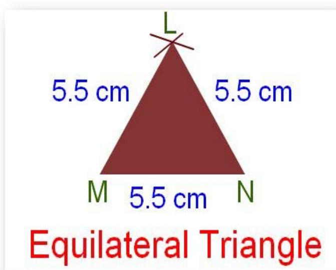


Auditory

Right angled isosceles triangle! A triangle in which two of its sides are equal and the angle between them is right angle is called a right angled isosceles triangle.

Visual

Picture of an equilateral triangle is shown.



Auditory

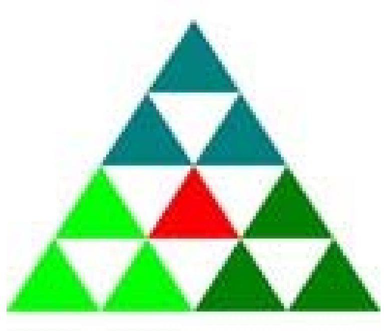
Equilateral triangle! A triangle in which all the three sides are equal in length is called an equilateral triangle.

<u>ACTIVITY</u>

An individual activity for children! Using scissors cut and make as many triangles from the given colour papers. Stick them in a chart paper and measure the six elements of the triangle. Also label them with types and measures.

PUZZLE

How many triangles are there in the following figure?



HOME ASSIGNMENT

Make a chart describing various types of triangles, its characteristics and examples from surroundings.

Eg: Right triangle-1 right angle, 2 acute angles-A right angle is formed when a ladder is placed on the floor forming 30° with the wall.

MODULE TEST-V

1. Use nine match sticks and make as many triangles. Also name things you have drawn.
2. Cite examples of articles at public places having triangular shapes in them.

Eg: Bridge

3. Construct toys and other playing articles using various types of triangles.

Eg: Yacht 

MODULE VI

QUADRILATERALS

Submodule-1	Types of Quadrilaterals
Submodule-2	Rectangle & Square

SUBMODULE - 1

TYPES OF QUADRILATERALS

OBJECTIVES

1. To make the learner know about quadrilaterals.
2. To enable the learner distinguish between various types of quadrilaterals.
3. To enable the learner understand angle sum property of a quadrilateral.
4. To apply the knowledge of square in solving puzzles.
5. To enable the learner use quadrilaterals creatively at particular situations.

CONTENT

QUADRILATERAL

A polygon having four sides and four angles is called a quadrilateral.

ANGLE SUM PROPERTY OF QUADRILATERAL

Sum of angles of a quadrilateral is 360°.

TYPES OF QUADRILATERALS

1. TRAPEZIUM

A quadrilateral is called trapezium if a pair of its opposite sides are parallel. If a trapezium has non parallel sides equal, it is called isosceles trapezium.

2. PARALLELOGRAM

A quadrilateral having two pair of opposite sides which are parallel and equal is called a parallelogram. Its opposite angles are equal.

3. RHOMBUS

A rhombus is a parallelogram whose all sides are equal, opposite sides are parallel and opposite angles are equal.

4. RECTANGLE

A rectangle is a parallelogram whose four angles right angles.

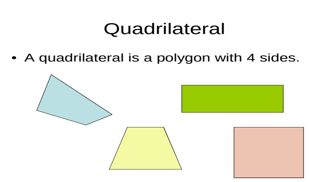
5. SQUARE

If the four sides of the rectangle are made equal then it is called a square.

PRESENTATION DESCRIPTION

Visual

Picture of some quadrilaterals are shown.

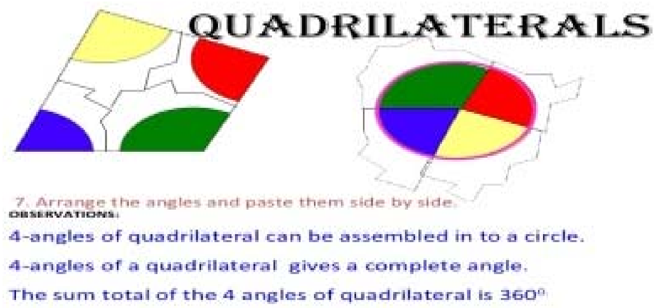


Auditory

A quadrilateral is a polygon having four sides and four angles. Many types of quadrilaterals are shown in the picture.

Visual

Animation of angle sum property of a quadrilateral is shown.

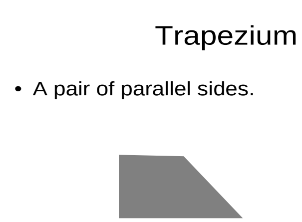


Auditory

Now, let us see the angle sum property of quadrilaterals. In this animation, a quadrilateral is shown. Then it is divided into two triangles with its diagonal. All the four angles of the quadrilateral are marked. Then each of them is picked and placed along a circle. We know that, interior angle of a circle is equal to 360°. Hence the sum of four angles of a quadrilateral is equal to 360°.

Visual

Picture of a trapezium is shown.



Auditory

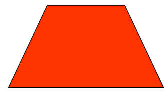
Now, let us see some types of quadrilaterals. Trapezium! If the two opposite sides of a quadrilateral are parallel, it is called a trapezium.

Visual

Picture of an isosceles trapezium is shown.

Isosceles trapezium

- A pair of parallel sides.
- Non-parallel sides are equal.



Auditory

We know that, a pair of opposite sides of a trapezium is parallel. If the other two non-parallel sides are equal in length, we call it as isosceles trapezium.

Visual

Picture of a parallelogram is shown.

Parallelogram

- Two pairs of parallel sides
- Opposite sides are equal.

Auditory

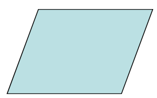
If both the pair of opposite sides of a quadrilateral is parallel and equal, we call it a parallelogram.

Visual

Picture of a rhombus is shown.

Rhombus

- Two pairs of parallel sides
- Four sides equal.



Auditory

If all the four sides of the parallelogram are equal we call it a rhombus.

Visual

Picture of a rectangle is shown.

Rectangle

- Two pairs of parallel sides;
- Opposite sides equal.
- Four right angles

Auditory

We are familiar with rectangles and squares. Now, what is the condition for a quadrilateral to be a rectangle? Both pair of opposite sides is parallel and equal.

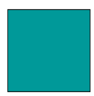
Also its four angles must be right angles. Then a quadrilateral becomes a rectangle.

Visual

Picture of a square is shown.

Square

- Two pairs of parallel sides.
- Four equal sides
- Four right angles



Auditory

If all the four sides of a rectangle are made equal, we get a square. That is, a square has two pair of parallel sides, four equal sides and four right angles.

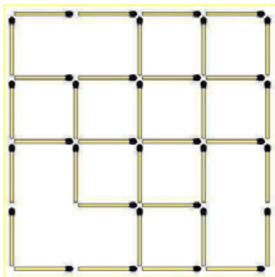
<u>ACTIVITY</u>

1. The students are grouped and each group is provided with a chart paper and sketch pencils. They are asked to draw their school using various types of quadrilaterals.

2. Make a flower using colour papers! First make five paper-cutting from the colour paper in the shape of a square. Then fold each of them like a kite. Then join the kite shaped papers as the petals of a flower and stick a straw stick for stem as seen below.

PUZZLE

How many squares are there in the following figure?



HOME ASSIGNMENT

Arrange four squares of same size and make various objects. Also name them.

SUBMODULE - 2

AREA AND PERIMETER

OBJECTIVES

1. To make the learner know about perimeter of a square.
2. To make the learner know about perimeter of a rectangle.
3. To make the learner know about area of a square.
4. To make the learner know about area of a rectangle.
5. To enable the learner solve puzzles involving squares.
6. To enable the learner apply area of squares creatively at particular situations.

CONTENT

PERIMETER

Perimeter is the distance around a closed figure.

PERIMETER OF A SQUARE

Perimeter of a square is the distance around it. That is four sides of equal length are to be added.

PERIMETER OF A RECTANGLE

Perimeter of a rectangle is the distance around it. That is two lengths and two breadths are to be added.

AREA

The amount of surface enclosed by a closed figure is called its area.

AREA OF A SQUARE

Area is the number of square units it takes to completely fill a square. Since its four sides are equal, area of a square is the square of its side.

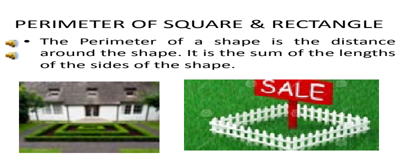
AREA OF A RECTANGLE

The area of a rectangle is the breadth times its length. That is area of the rectangle is the product of its length and breadth.

<u>PRESENTATION DESCRIPTION</u>

Visual

Occasions of finding perimeter of square and rectangle are shown.



Auditory

Consider occasions like making a foot path around a garden, fencing a plot, etc. In such cases we find perimeter of the shape. Now let us see how to find perimeter of two common and basic shapes – square and rectangle.

Visual

Picture of a square for illustrating its perimeter is shown.

Auditory

We see that, perimeter is the distance around a closed figure. For a square, there are four sides of equal length. Hence distance around a square that is the perimeter is four times its side.

For example, the given square having side equal to 3meter has its perimeter 3X4=12 meter.

Visual

Picture of a rectangle for illustrating its perimeter is shown.

Auditory

Now consider a rectangle. We know that rectangle has two pair of parallel sides. That is two lengths and two breadths are to be added. Hence perimeter of a rectangle is the sum of two times its length and two times its breadth. That is twice the sum of its length and breadth.

For example, the given rectangle has length 5 meter and breadth 3 meter. Hence its perimeter is 2(3+5) equal to 16 meters.

Visual

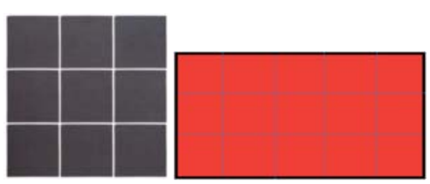
Pictures of instances illustrating area of a square and rectangle are shown.

Auditory

Now, consider the instances of paving tiles in a room or sticking wall paper on a wall or buying a table cloth etc. in such cases we find the area of a square or rectangle.

Visual

Animation of area of a square and then area of a rectangle is shown.



Auditory

Consider paving a square shaped room of 3 meter sides using tiles of 1 meter sides. Hence we need 3X3 equal to 9 tiles to complete paving tile in the room. That is area of a square is side X side which is equal to square of a side.

If the room is rectangular in shape, we have to fill the room breadth times its length. In this figure, 3 meter is the breadth and 5 meter is the length. Then area is equal to 3X5 equal to 15 meters.

That is area of a rectangle is equal to length X breadth.

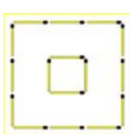
ACTIVITY

A group activity! Measure the sides of classrooms and various other parts of your school using a measuring tape. Mark them in the sketch of your school you already drawn in the previous activity. Now try to find area of various parts of your school such as classrooms, library, laboratory, office, stage etc.

Also write scale that you have chosen. Eg: If 10 meter is the actual measurement, it can be reduced for convenience and mark in the sketch by taking 10 centimeters.

PUZZLE

Can you move only four match sticks to form three squares?



HOME ASSIGNMENT

Find the area of your house, rooms, yard etc. Also sketch the house with all the measurements you took. Also write scale that you have chosen.

MODULE TEST-VI

1. Using various quadrilaterals you know, construct useful articles (drawings) and name them.
2. Using squares draw any furniture of your choice.
3. Using quadrilaterals design various learning aids.

   Eg. Letter pad

MODULE-VII

CIRCLES

Submodule 1	Circle – The concept of circles
Submodule 2	Circle – Properties

SUBMODULE - 1

CIRCLE – CONCEPTS

OBJECTIVES

1. To make the learner know about the centre and radius of a circle.
2. To make the learner know about the interior and exterior of a circle.
3. To make the learner differentiate between circles and non-circles.
4. To enable the learner apply circles in solving puzzles.
5. To enable the learner use concept of circle creatively at particular situations.

CONTENT

CIRCLE - CENTRE AND RADIUS

Circle is a closed curve consisting of all points at a given distance from a fixed point within. The fixed point within the circle is called the centre of the circle. The line segment joining the centre to any point on the circle is called the radius of the circle.

INTERIOR AND EXTERIOR

The interior of a circle is the set of all points whose distance from the centre is less than the radius. The exterior of a circle is the set of all points whose distance from the centre is greater than the radius.

PRESENTATION DESCRIPTION

LAND AND POND GAME

Draw a circle. One participant in the game becomes the catcher by a lucky draw. The catcher if say land all the other participants should stay outside the circle. If the catcher say pond, all the students should stay inside the circle.

After playing the game for a while, the teacher explains parts of the circle from the context of the game. The shape of the pond is called circle. The pond is an example for interior of the circle and land is an example for exterior of the circle.

Visual

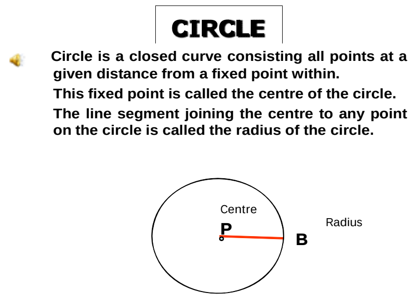
Picture of circular things from surroundings are shown.

Auditory

We are familiar with circular things like bangles, rings, plates etc.

Visual

Picture illustrating the circle, its center and radius are shown.

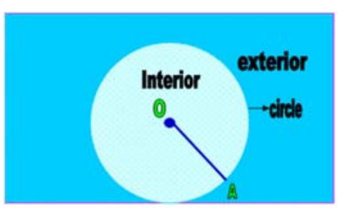


Auditory

Now, what is a circle? Circle is a closed curve consisting of all points at a given distance from a fixed point within. This fixed point inside the circle is called the centre of the circle. The line segment joining the centre to any point on the circle is called the radius of the circle.

Visual

Picture illustrating the interior and exterior is shown.



Auditory

A Circle has an interior as well as an exterior region as shown. Otherwise we can say that the circle is the collection of all the points equidistant from an interior point. Here the line segmentOA is the radius of the circle. The exterior or region outside the circle is shaded bright blue and interior or region inside the circle is shaded pale blue.

ACTIVITY

Activity to find circles and non-circles! A basket full of coloured papers of circular and non circular shapes is given to students. The task is to differentiate circles and non-circles only through folding.

Fold the paper continuously three to five times. If the fold exactly coincides, we can conclude that 'if distance from the centre to any point on the curve is a constant, then the curve is called a circle; otherwise not a circle.'

INTERACTIVE SESSION

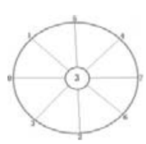
What all things appear to be circular in their surroundings? (All the petals arranged in a circular manner.) What all things can be used to draw circles? What are the peculiarities of the shape 'circle'?

Why wheels, cross-section of tubes, pipes as circle only.

Then the teacher discusses with the children about circular things around them such as bangles, bottles, rings, tiffin box, wheels etc.

PUZZLE

A magic circle of numbers is given. Write numbers 0 to 7 in each circle so that sum of three numbers along each diameter is 10.



HOME ASSIGNMENT

Make a list of circular objects from your surroundings.

SUBMODULE - 2

CIRCLE-PROPERTIES

OBJECTIVES

1. To make the learner know about diameter.
2. To make the learner know about semi-circle.
3. To enable the learner know about concentric circles.
4. To make the learner know the relationship between sector and arc.
5. To make the learner distinguish between chord and segment.
6. To enable the learner find circumference of circles.
7. To enable the learner apply circles in solving puzzles.
8. To enable the learner deal creatively uses the concepts of circles and semicircles.

CONTENT

CHORD

The line segment joining any two points on the circle is called a chord of the circle.

DIAMETER

A chord which passes through the center of the circle is called the diameter. Diameter of a circle is double the length of its radius.

CIRCUMFERENCE

The distance around the circular region is known as its circumference.

ARC

Arc of a circle is a portion of the circumference of the circle. An arc having length more than half the circumference of the circle is called a major arc and an arc having length less than half the circumference of the circle is called a minor arc. The angle subtended by the arc at the center is called the central angle.

SEMI CIRCLE

A diameter of a circle divides it into two equal parts; each part is called a semi-circle.

SECTOR

Interior part of a circle within a pair of radii and an arc between them is called a circle.

SEGMENT

Interior part of a circle formed by a chord and an arc is called a segment.

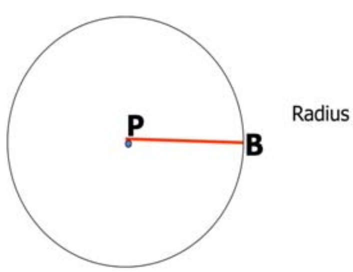
CONCENTRIC CIRCLES

Concentric circles are circles with same center but different radius.

PRESENTATION DESCRIPTION

Visual

Picture demonstrating the radius of a circle is shown.

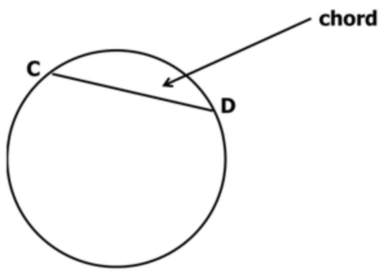


Auditory

Now let us see some characteristics of a circle. We know, the line-segment drawn from the centre of the circle to any point on the circle is its radius.

Visual

Picture demonstrating the chord of a circle is shown.

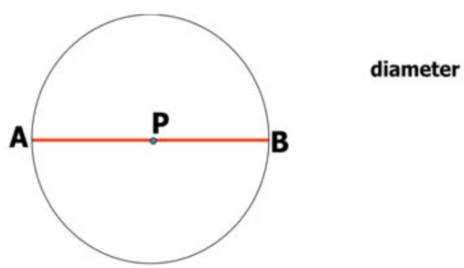


Auditory

Chord is a line-segment joining any two parts of a circle.

Visual

Picture demonstrating the diameter of a circle is shown.

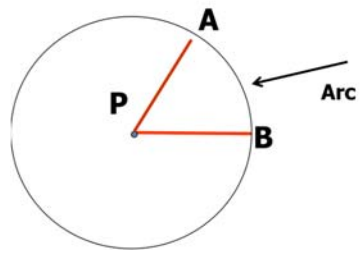


Auditory

If the chord passes through the centre of the circle it is called the diameter of the circle. We can say that diameter is the largest chord of a circle. We can see that diameter is double the length of radius of a circle. That is d = 2r.

Visual

Picture demonstrating the arc of a circle is shown.

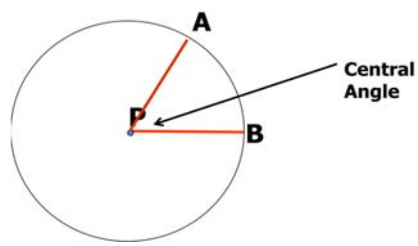


Auditory

The curve joining any two points on a circle is an arc.

Visual

Picture demonstrating the central angle of a circle is shown.

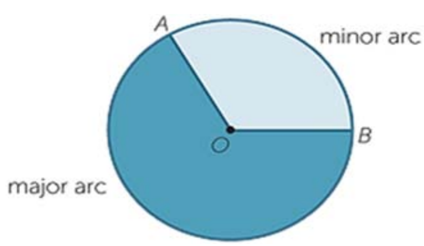


Auditory

The angle subtended at the centre by an arc is called the central angle.

Visual

Picture demonstrating the major arc and minor arc of a circle is shown.

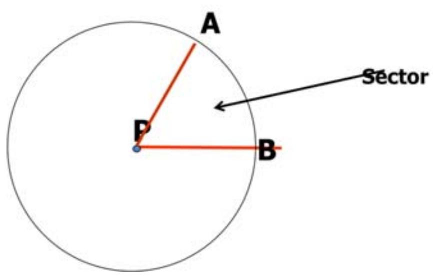


Auditory

If the arc length is larger than half the length of the circle it is called a major arc. And, if it is smaller than half the length of the circle, it is called a major arc.

Visual

Picture demonstrating sector of a circle is shown.

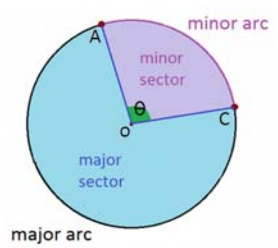


Auditory

The portion of a circle having an arc and two radii as boundaries is called a sector.

Visual

Picture demonstrating the major sector and minor sector is shown.

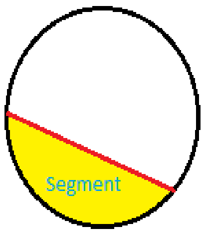


Auditory

If the arc involved is a major arc, the sector is called a major sector. And if the arc involved is a minor arc, the sector is called a minor sector.

Visual

Picture demonstrating segment of a circle is shown.

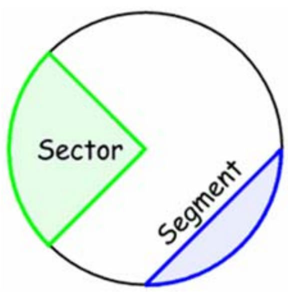


Auditory

Now, a segment! The portion of a circle having an arc and a chord as boundaries is called a segment. It need not pass through the centre.

Visual

Picture differentiating the sector and segment of a circle is shown.

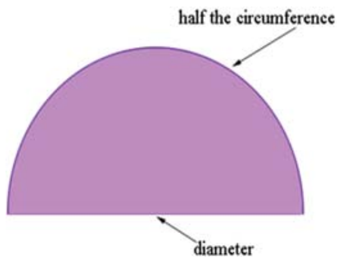


Auditory

Now let us differentiate between a sector and a segment. The area shaded in green is a sector. It has two radii and an arc as the boundaries. The area shaded in blue is a segment. Its boundaries are a chord and an arc.

Visual

Picture demonstrating semi-circle is shown.

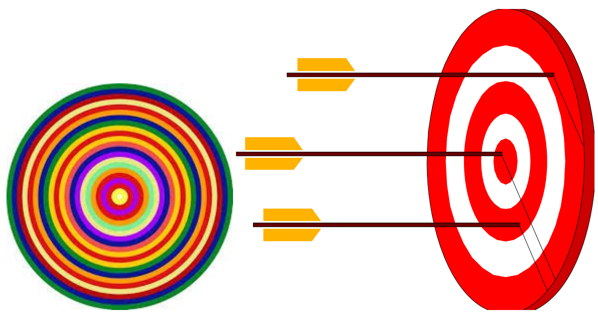


Auditory

If it passes through the centre, the segment is called a semi-circle. The boundaries of a semi-circle are a diameter and half length of the circle.

Visual

Picture of a shooting target is shown to illustrate concentric circles.



Auditory

You may have seen shooting targets. Here all the circles have different radii but a common centre. Such circles having the same centre but different radii are called concentric circles.

Visual

Pictures of various occasions of finding circumference of a circle like an athlete running in a circular track, fencing a circular area, making a garland of flowers are shown.

Auditory

Now consider making a circular garland, the distance covered when an athlete running around a circular track or fencing a circular plot, etc.

Visual

Picture demonstrating circumference of a circle is shown.

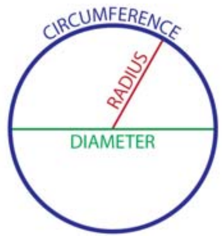
Auditory

Here we find the distance around a circular shape. You have learnt perimeter of rectangle and square. Here perimeter of a circle! It is called circumference because it has no sides with straight lines but a curved line.

<u>ACTIVITY</u>

A group activity for children! Working model of a circle is made by students which can demonstrate all the properties of a circle such as centre, radius, diameter, chord, arc, segment, sector, semi circle etc.

The materials needed for making this model are a piece of card board, a thermocol sheet, threads and needles.

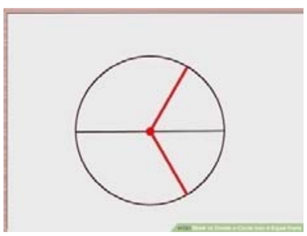
Eg: 

PUZZLE

The circular clock is broken into four pieces. When added the numbers of each piece, we get twenty. Show how the clock is broken.

HOME ASSIGNMENT

1. Divide the circle into pieces using only three sticks, as many possible ways as you can.

Eg: 

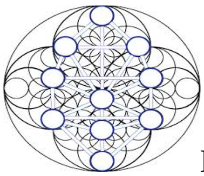
2. Draw some patterns on concentric circles. Eg:

MODULE TEST-VII

1. Find various instances where patterns of circles are seen in your surroundings.

Eg. Circles formed in water surface when stones are thrown.

2. Using circles of various sizes, form as many designs as possible in a paper. Extra drawings (if necessary) are allowed. Name the object you visualized in them.



Eg: Floral design

3. Draw a vehicle of your choice and identify circles and parts of circle in it.

MODULE-VIII

THREE DIMENSIONAL GEOMETRY

Submodule-1	Identification of Three Dimensional Figures
Submodule-2	Classification of Three Dimensional Figures

SUBMODULE - 1

IDENTIFY THREE DIMENSIONAL FIGURES

OBJECTIVES

1. To make the learner know about three dimensional figures.
2. To enable the learner distinguish between two and three dimensional figures.
3. To make the learner identify characteristics of three dimensional figures.
4. To make the learner apply knowledge of three dimensional figures in solving puzzles.
5. To make the learner create various three dimensional figures by assembling two dimensional figures.

CONTENT

DIMENSIONS

One dimensional figure is that having length only.

Two dimensional figure is that having length and breadth but no thickness.

Three dimensional figure is that having length, breadth and thickness.

PRESENTATION DESCRIPTION

Game of Snake and Ladder:- The game of snake and ladder is used to introduce the concept of three dimensional figures. The children are grouped and snake and ladder set is provided to each group. The rules are explained and allow them to play a complete round.

Then a large cube is used for demonstration of three dimensional figures. Also various other still models of three dimensional figures are used for demonstration. Then the power point presentation is shown.

Visual

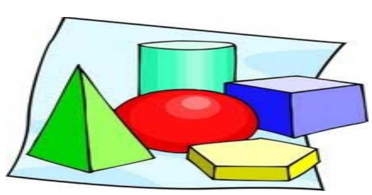
Animation of a point transforming into one dimensional figure, and then becoming two dimensional and at last a three dimensional figure is shown.

Auditory

A point! Points along a straight path form a line. Many lines join together to make a plane. Many congruent planes form a three dimensional figure or solid.

Visual

Picture of three dimensional figures like cube, cylinder and cone are shown.



Auditory

Let us see some examples for three dimensional figures as shown.

ACTIVITY

Two dimensional figures like squares, rectangles and triangles are distributed to group of students. They are asked to place congruent figures as super positioned. Gradually the two dimensional figure transforms to a three dimensional one.

PUZZLE

A wooden cube is painted pink and it was again cut into pieces as shown in the figure.

1. How many small cubes are there?
2. How many small cubes have only one pink face?
3. How many small cubes have only two pink faces?
4. How many small cubes have three pink faces?
5. How many small cubes have no pink face?

HOME ASSIGNMENT

Identify and make a list of various three dimensional objects in the class room.

Eg: Pencil box

SUBMODULE - 2

CLASSIFICATION OF THREE DIMENSIONAL SHAPES

OBJECTIVES

1. To make the learner know about various three dimensional figures.
2. To make the learner identify a 3D shape with its corresponding net.
3. To enable the learner apply the concept of three dimensions in solving puzzles.
4. To enable the learner assemble various three dimensional figures and to make it a meaningful entity.

CONTENT

PRISM

It is a three dimensional figure having two congruent faces one at the base and the other at the top. It also has four rectangular lateral faces. The prism is named after the shape of face polygon.

Prism	**Total no. of faces**	**Lateral faces**	**Base Polygon**
Rectangular Prism (Cuboid)	6	4 Rectangles	Rectangle
Square Prism	6	4 Rectangles	Square
Cube	6	4 Rectangles	Square
Triangular Prism	5	3 Rectangles	Triangle

PYRAMID

It has only one base which is a polygon. The lateral faces are triangular in shape. The pyramid is named after the shape of base polygon.

CONE

A cone has a circular base and a curved lateral face.

CYLINDER

It is a three dimensional figure with two circular faces one at the top and the other at the bottom. Its lateral face is a curved one.

SPHERE

It has only one face which is a curved one.

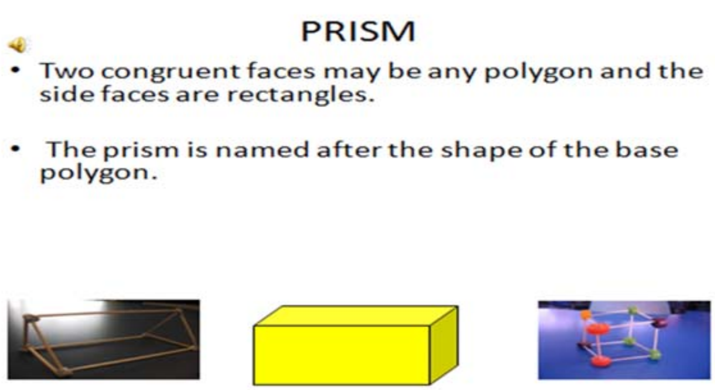
HEMI-SPHERE

It has a circular base and a curved lateral face.

PRESENTATION DESCRIPTION

Visual

Power point presentation explaining prism and its properties is shown.

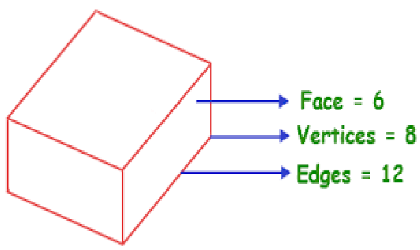


Auditory

Prism is a three dimensional figure having six faces. It has two congruent faces, one at the top and other at the bottom. The prism is named after the shape of base polygon. It also has several lateral faces and all of them are rectangles.

Visual

Picture of a rectangular prism or cuboid is shown to describe its properties.



Auditory

A rectangular prism! Here, all the 6 faces are rectangles. It has eight vertices and twelve edges.

Visual

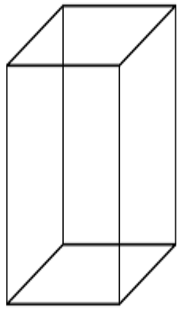
Example for rectangular prism is shown.

Auditory

Bricks are examples for rectangular prism.

Visual

Picture of a square prism is shown to describe its properties.

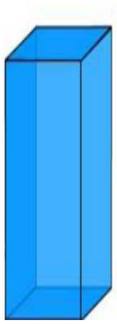


Auditory

A square prism! Two faces-at the top and bottom- are squares and the four lateral faces are rectangles. All together it has six faces. It also has eight vertices and twelve edges.

Visual

Examples for square prism are shown.

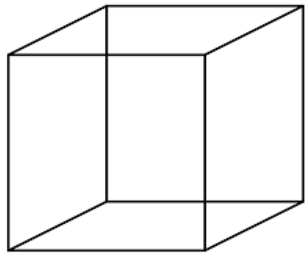


Auditory

Here we have examples for square prism.

Visual

Picture of a cube is shown to describe its properties.



Auditory

A cube! It has 6 congruent faces, all of them are squares. It also has eight vertices and twelve edges.

Visual

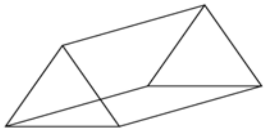
Picture illustrating for cube are shown.

Auditory

Examples for cubes are shown.

Visual

Picture of a triangular prism is shown to describe its properties.

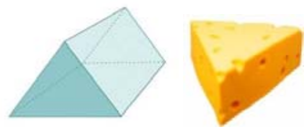


Auditory

A triangular prism! It has two triangular faces and three rectangular faces. It has six vertices and nine edges.

Visual

Picture illustrating triangular prism are shown.

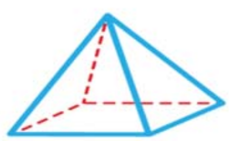


Auditory

Example for triangular prism is shown.

Visual

Picture of pyramid is shown to describe its properties.

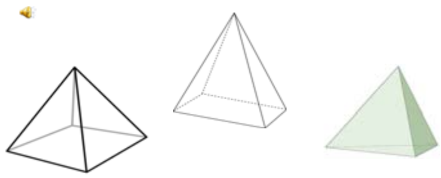


Auditory

A Pyramid! It has only one base which is a polygon. The lateral faces are triangular in shape. The pyramid is named after the shape of base polygon.

Visual

Picture illustrating types of pyramids are shown.



Auditory

Various types of pyramids are shown, like square pyramid, rectangular pyramid, triangular pyramid etc.

Visual

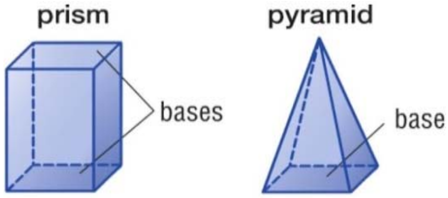
Picture of pyramids are shown.

Auditory

Example for pyramid is shown.

Visual

Picture of comparison of a prism and a pyramid is shown to describe its properties.

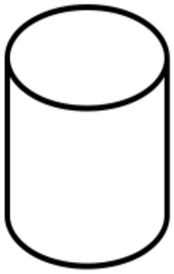


Auditory

A comparison of prism and pyramid are shown. A prism has two base polygons whereas a pyramid has only one base. The lateral faces of a prism are rectangular in shape whereas those of a pyramid are triangular shape.

Visual

Picture of a cylinder is shown to describe its properties.



Auditory

A Cylinder! It is a three dimensional figure with two circular faces one at the top and the other at the bottom. Its lateral face is a curved one. It has two curved edges but no vertex at all.

Visual

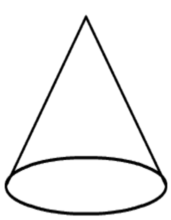
Picture illustrating cylinder is shown.

Auditory

Examples for cylinders are shown.

Visual

Picture of a cone is shown to describe its properties.



Auditory

A Cone! It has a circular base and a curved lateral face. It has one vertex and one curved edge.

Visual

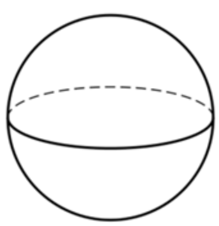
Picture of an ice-cream for illustrating cone is shown.

Auditory

Example for cone is shown.

Visual

Picture of a sphere with example is shown to describe its properties.



Auditory

A Sphere! It is a three dimensional figure having only one face which is a curved one. It has no vertex and edges.

Visual

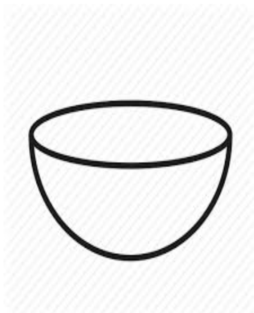
Picture of a globe as an example for sphere is shown.

Auditory

Examples for spheres are shown.

Visual

Picture of a hemi-sphere is shown to describe its properties.



Auditory

A Hemi-Sphere! It has a circular base and a curved lateral face. It has one curved edge and no vertex.

Visual

Picture illustrating for hemi-sphere is shown.

Auditory

Example for hemi-spheres is shown.

ACTIVITY

A group activity! From the given colour papers make as many net of three dimensional figures as possible. The group that makes maximum number of net of three dimensional figures is the winner.

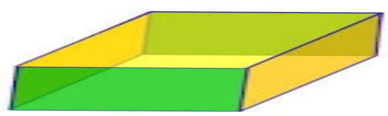
PUZZLE

Numbers 1, 2, 3 and 4 on consecutive sides, 5 on top and 6 at the bottom are written on the faces of the cube. The cube is rotated and 1 comes at the top face, then which number is at the bottom side?

HOME ASSIGNMENT

Using thermocol pieces make various three dimensional figures. Eg:

Eg: Box



MODULE TEST-VIII

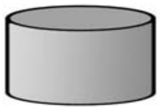
1. Identify various Three Dimensional figures from public places.

Eg: Pencil box, chalk, Phone etc.

2. Using various three dimensional figures, make the theme ‘My sweet Home’

Eg: 

3. Using three dimensional figures form as many objects as possible and identify them with your household articles.

Eg: Kitchen vessel 

Appendix H

Certificates from Experts

CERTIFICATE

This is to certify that Ms. Jinu M. K., Senior research Fellow, Farook Training College, Research Center in Education, Kozhikode has discussed her research work with me-the content in the package and items to be given at the end of each module.

I have gone through the package and tests of mathematical creativity and have suggested appropriate modifications wherever necessary.

Signature:
Dr. V. Sumangala
Former HoD & Professor in Education
University of Calicut

CERTIFICATE

This is to certify that Ms. Jinu M. K., Senior Research Scholar, Farook Training College, Research centre in Education, Kozhikode, has discussed her research work with me- the content of the Package on Geometry and the items to be given at the end of each module.

I have gone through the Package on Geometry and the tests of Mathematical Creativity and have suggested appropriate modifications wherever necessary.

Signature: Mercy 1/12/2018

Mercy P. R.

Principal (Rtd.)

DIET Kottayam

Appendix I

RATING SCALE

Following is a rating scale based on 'the Package on Geometry'. Please rate each dimension given below.

Sl. No.	Dimensions	Low	Medium	High
1	The content is appropriate			
2	Activities are suitable			
3	It is practicable			
4	The presentation is simple			
5	The presentation is sequential			
6	It has the ability to arose and sustain pupil motivation and interest			
7	It is comprehensive			
8	It is student friendly			
9	It is capable of fluent production of mathematical ideas			
10	It facilitate divergent thinking			
11	It gives opportunity for elaboration or detailing of mathematical situations			
12	It facilitates original thinking			

RATING SCALE

Following is a rating scale based on 'the Package on Geometry'. Please rate each dimension given below.

Sl. No.	Dimensions	Low	Medium	High
1	The content is appropriate			✓
2	Activities are suitable			✓
3	It is practicable			✓
4	The presentation is simple			✓
5	The presentation is sequential			✓
6	It has the ability to arose and sustain pupil motivation and interest			✓
7	It is comprehensive			✓
8	It is student friendly			✓
9	It is capable of fluent production of mathematical ideas			✓
10	It facilitate divergent thinking			✓
11	It gives opportunity for elaboration or detailing of mathematical situations			✓
12	It facilitates original thinking			✓

Sreelatha . B. Nair
UPST
CMGHSS Kuttur

C.M. GOVT. HIGHER SECONDARY SCHOOL
School Code: 72015
UDISE Code: 32071210901
KUTTUR

Sreelatha . B. Nair

RATING SCALE

Following is a rating scale based on 'the Package on Geometry'. Please rate each dimension given below.

Sl. No.	Dimensions	Low	Medium	High
1	The content is appropriate			✓
2	Activities are suitable			✓
3	It is practicable			✓
4	The presentation is simple			✓
5	The presentation is sequential			✓
6	It has the ability to arose and sustain pupil motivation and interest			✓
7	It is comprehensive			✓
8	It is student friendly			✓
9	It is capable of fluent production of mathematical ideas			✓
10	It facilitate divergent thinking			✓
11	It gives opportunity for elaboration or detailing of mathematical situations			✓
12	It facilitates original thinking			✓

C.M. GOVT. HIGHER SECONDARY SCHOOL
School Code: 722015
UDISE Code: 32071210901
KUTTUR

BINDU. V. A
UPST
CMGHSS KUTTUR
Bindu

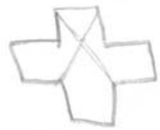
Appendix J_1

Specimen copy of response sheets of pre-test

on Mathematical Creativity

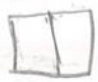
PRE

1



pot

Table



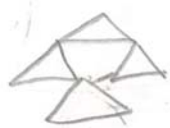
book

Step

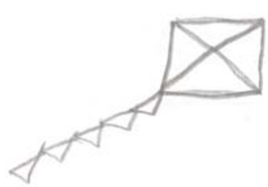
2

Flower

house

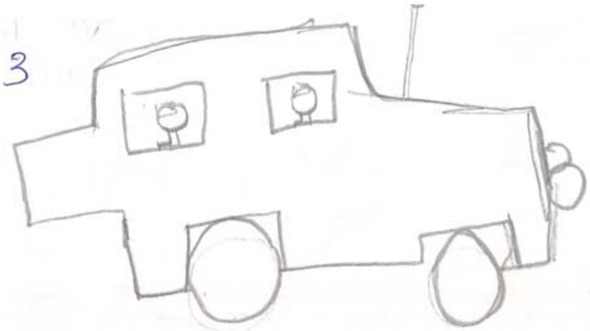


bird



Kite

3



Jeep

cincle
retangle
square

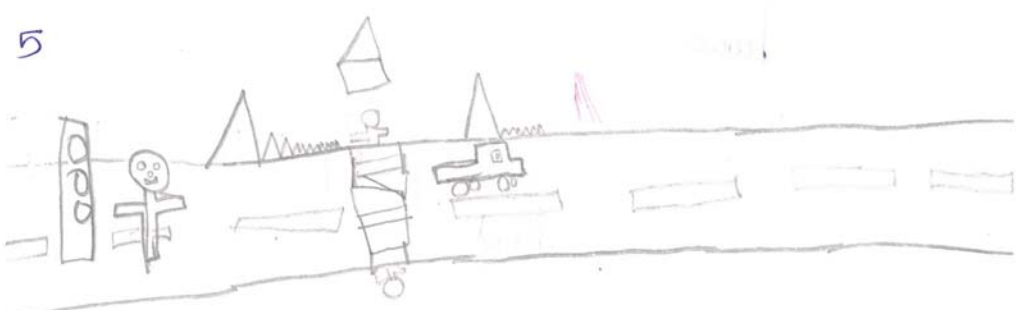
Lorry

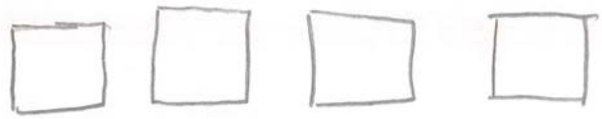
Circle
retangle
squre

4

bottle mala mirror house

5



9 

Four books

10 . 

~~DE~~ TEDibean

Appendix J_2

Specimen copy of response sheets of post-test

on Mathematical Creativity

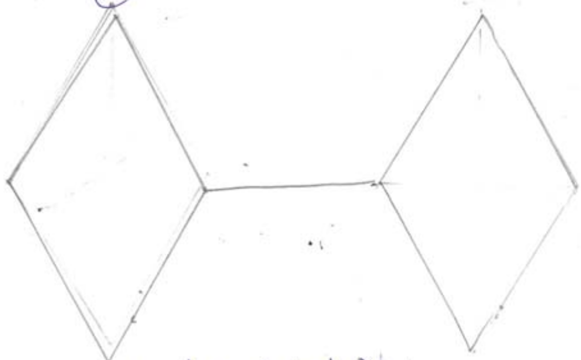
1.

(1)

Square & Triangle Pattern (Tent)

House

(2)



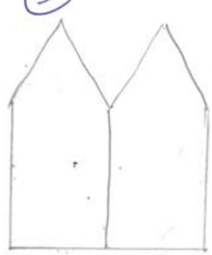
Diamond shape (Window)

Flower

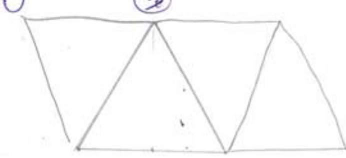
(4)

rectangles (bricks)

(3)

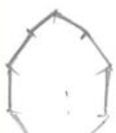


(5)



Triangles (Tile)

Pentagons (wall)

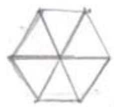


heptagon

Grill

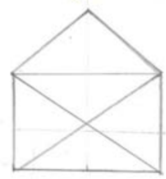
Q

①



Hexagon ball

②

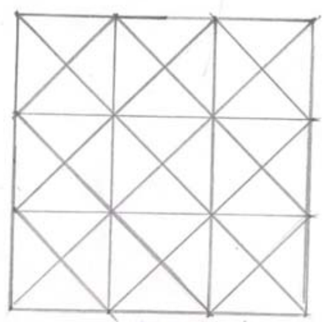


Letter

③

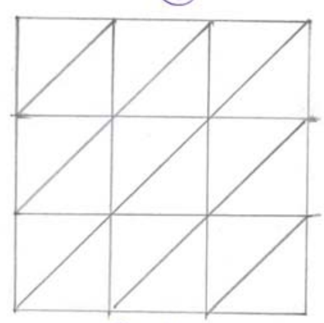
Sand clock

④



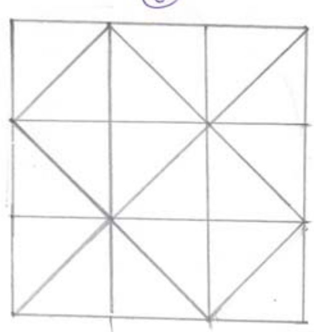
Grill

⑤

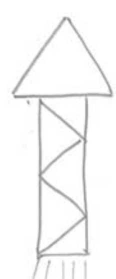


Gate

⑥

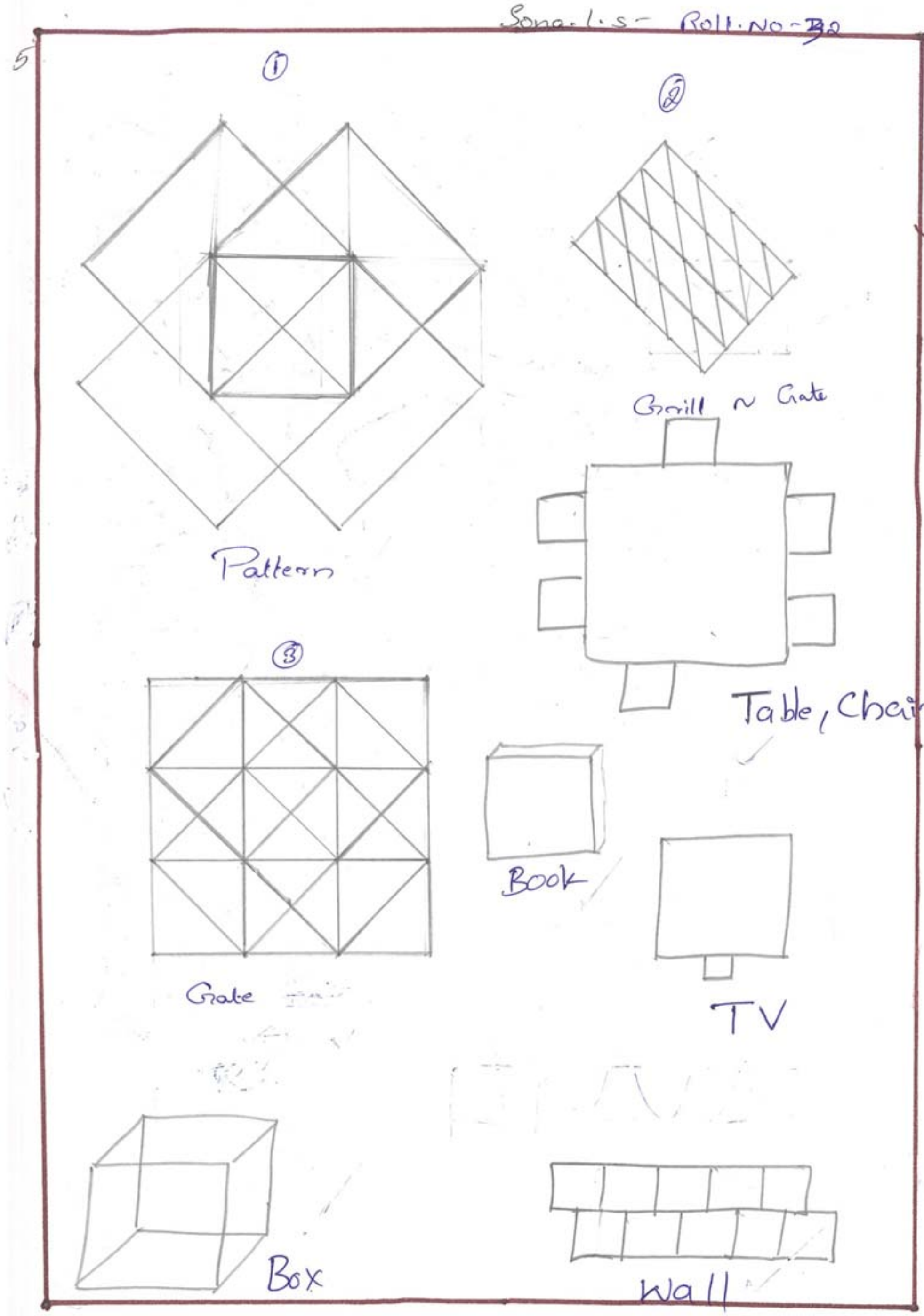


Tiles



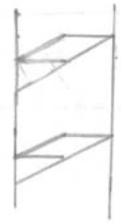
Rocket

Sona. L.S - Roll. No - 32

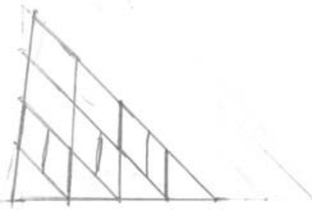


Sona. l.s Roll.NO-32

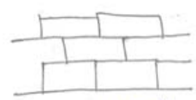
6



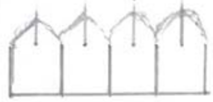
2 tair bed



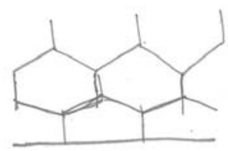
ramb.



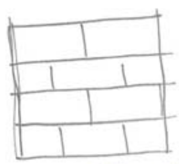
wall



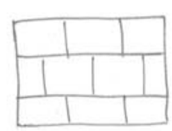
wall ~ മതിൽ



Tile

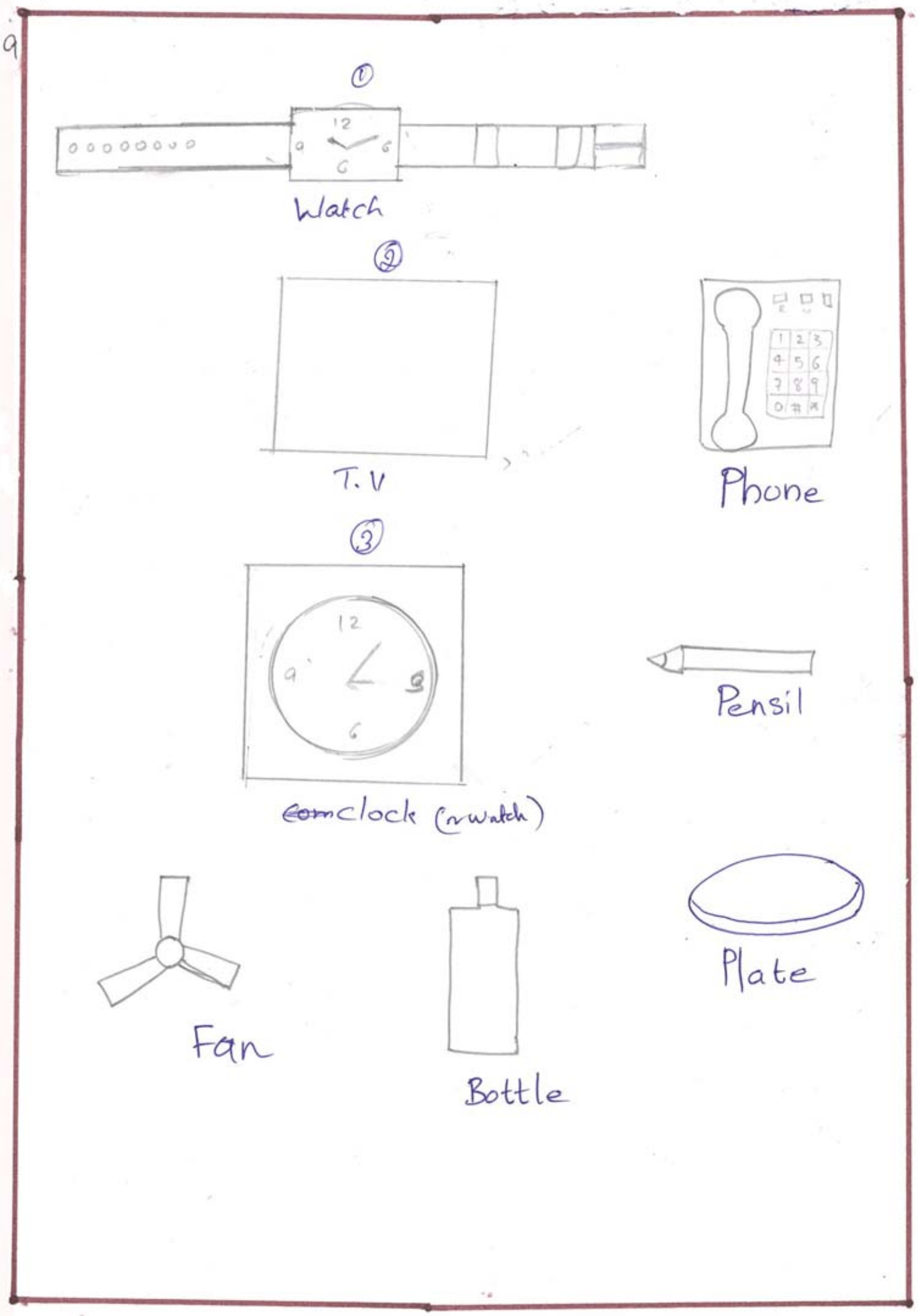


Shelf



Grill

9



1

Sweet

2

Face

3

Pillow

4

Clock

5

Pond.

Plate

[illegible]

Appendix K

Photographs of participation of the students in the experimental group