EFFECT OF VIRTUAL LEARNING ENVIRONMENT USING GEOGEBRA ON PROBLEM SOLVING ABILITY IN GEOMETRY OF SECONDARY SCHOOL STUDENTS

Thesis

Submitted for the Degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

By

RISHAD KOLOTHUMTHODI

Supervised by

Dr. MANOJ PRAVEEN G.

Associate Professor

Department of Education

University of Calicut

FAROOK TRAINING COLLEGE

RESEARCH CENTRE IN EDUCATION

UNIVERSITY OF CALICUT

2022

DECLARATION

I, RISHAD KOLOTHUMTHODI, do hereby declare that this thesis entitled as **EFFECT OF VIRTUAL LEARNING ENVIRONMENT USING GEOGEBRA ON PROBLEM SOLVING ABILITY IN GEOMETRY OF SECONDARY SCHOOL STUDENTS** is a genuine record of the research work done by me under the supervision of **Dr. Manoj Praveen G.**, Associate Professor, Department of Education, University of Calicut; and that no part of the thesis has been presented earlier for the award of any Degree, Diploma, Associateship or other similar title of recognition in any other University.

Place: Farook Training College

Rishad Kolothumthodi

Date: 29.12.2022

FAROOK TRAINING COLLEGE P.O. Farook College Pin: 673632

23/03/2023 15:40

Dr. MANOJ PRAVEEN G.
Associate Professor
Department of Education
University of Calicut

Certificate

This is to certify that the thesis entitled **EFFECT OF VIRTUAL LEARNING ENVIRONMENT USING GEOGEBRA ON PROBLEM SOLVING ABILITY IN GEOMETRY OF SECONDARY SCHOOL STUDENTS** is an authentic record of research work carried out by **Mr. Rishad Kolothumthodi**, 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 for any other Degree, Diploma, Associateship or other similar title of recognition in any other University.

Contents in the hardcopy and softcopy are the same.

Dr. MANOJ PRAVEEN G.
(Supervising Teacher)

Place: C.U.Campus

Date: 30/12/2022

Acknowledgement

The researcher is grateful and feels blessed and accomplished as the work of the present doctoral thesis winds up. The divine blessings and the wonderful people around me need commendable mention in this achievement.

I praise the **Almighty** *for his bountiful Mercy and having strengthened me throughout the tenure of the present study.*

I offer my sincere gratitude to **Dr. Manoj Praveen G.***, Associate Professor, Department of education, University of Calicut, for his intellectual supervision, advice and guidance throughout my research work. I am indebted to acknowledge him for the encouraging mentorship and innovative suggestions that led the researcher to tread the path less taken.*

I expresses profound thanks to **Prof.(Dr.) T. Mohamed Saleem***, Principal, Farook Training College for providing all possible facilities and concern to discharge my duties both as a faculty member and a Part-time Research Scholar. His valuable advice, inspiration and constant support throughout the study was priceless as a friend and the head of the institution.*

Words can't express my respect and cordial gratitude to Dr. C.A Jawahar & Prof. A. Fasiludheen, former Principals, Farook Training College who have continuously encouraged and extended all their support during their tenure as Principals of this Research Centre.

I extend my gratefulness to the team of Teaching staff, Research Scholars, Non Teaching Staff and Library Staff for all the support provided in the tenure of my research work at my research centre. Special vote of thanks to my colleagues Dr. K. Vijayakumari, Dr. Irshana Shahnaz U., Mr. Nowfal C, Dr. Muhammed Nasimudheen, for their valuable inputs and suggestions which helped me a lot in the completion of the study.

I would like to express my deep sense of gratefulness toDr. Muhammed K.V, Assistant Professor, SPS, MG University, Kottayam and Dr. Shaheed Ali, K, Lecturer, DIET Palakkad for their timely guidance and assistance.

My joy knows no bounds in expressing my cordial gratitude to all the subject and technology experts who have spent their valuable time with me in moulding this research work to perfection.

This section cannot be complete without expressing words of owe to all my family members who have showered unbounded support during this study and throughout my life. Mere acknowledgement may not redeem the debt I owe to my better half Dr. Sulafa as she is the greatest motivator and catalyst in making this dream to materialize. I express my deepest love to my adorable kids AyshaZiya and Zayan who sacrificed lots of their fun time for this cause.

I profoundly thanks Mr. Ramprakash, Infratec, Calicut University, for printing and binding the thesis. Last, but not the least I acknowledge my friends, relatives and all those who have directly and indirectly assisted in completion of this work.

Farook Training College **Rishad Kolothumthodi**

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter	*Title*	*Page No.*
I	INTRODUCTION	1-24
II	REVIEW OF RELATED LITERATURE	25-146
III	METHODOLOGY	247-190
IV	ANALYSIS AND INTERPRETATION OF DATA	191-252
V	SUMMARY, FINDINGS AND CONCLUSION	253-270
VI	RECOMMENDATIONS	271-276
	REFERENCES	277-293
	APPENDICES	

LIST OF TABLES

Table No.	Title	Page No.
1.	Break up of Sample Selected for the Study	161
2.	Component wise Values of Pearson's Product Moment Coefficient of Correlation of Problem Solving Ability Test	167
3.	Modules in the Virtual Learning Environment	176
4.	Statistical Constants of the Pretest Scores of the Variables for the Experimental Group – Total sample	197
5.	Statistical Constants of the Pretest Scores of the Variables for the Experimental Group – Subsample Boys	197
6.	Statistical Constants of the Pretest Scores of the Variables for the Experimental Group – Subsample Girls	198
7.	Statistical Constants of the Pretest Scores of the Variables for the Control Group - Total Sample	200
8.	Statistical Constants of the Pretest Scores of the Variables for the Control Group – Subsample Boys	200
9.	Statistical Constants of the Pretest Scores of the Variables for the Control Group – Subsample Girls	201
10.	Statistical Constants of the Posttest Scores of the Variables for the Experimental Group – Total Sample	203
11.	Statistical Constants of the Posttest Scores of the Variables for the Experimental Group – Subsample Boys	203
12.	Statistical Constants of the Posttest Scores of the Variables for the Experimental Group – Subsample Girls	204
13.	Statistical Constants of the Posttest Scores of the Variables for the Control Group – Total Sample	206
14.	Statistical Constants of the Posttest Scores of the Variables for the Control Group – Subsample Boys	206
15.	Statistical Constants of the Posttest Scores of the Variables for the Control Group – Subsample Girls	207

Table No.	Title	Page No.
16.	Statistical Constants of the Gain Scores of the Variables for the Experimental Group – Total Sample	209
17.	Statistical Constants of the Gain Scores of the Variables for the Experimental Group – Subsample Boys	209
18.	Statistical Constants of the Gain Scores of the Variables for the Experimental Group – Subsample Girls	210
19.	Statistical Constants of the Gain Scores of the Variables for the Control Group –Total Sample	212
20.	Statistical Constants of the Gain Scores of the Variables for the Control Group - Subsample Boys	212
21.	Statistical Constants of the Gain Scores of the Variables for the Control Group – Subsample Girls	213
22.	Results of Test of Significance of Difference in Mean Pretest Scores and Mean Posttest Scores of Problem Solving Ability in Geometry of Experimental Group - Total Sample	216
23.	Results of Test of Significance of Difference in Mean Pretest Scores and Mean Posttest Scores of Problem Solving Ability in Geometry of Experimental Group – Subsample Boys	218
24.	Results of Test of Significance of Difference in Mean Pretest Scores and Mean Posttest Scores of Problem Solving Ability in Geometry of Experimental Group – Subsample Girls	220
25.	Results of Test of Significance of Difference in Mean Posttest Scores of Problem Solving Ability in Geometry between Experimental and Control Groups-Total Sample	223
26.	Results of Test of Significance of Difference in Mean Posttest Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Boys	225
27.	Results of Test of Significance of Difference in Mean Posttest Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Girls	227
28.	Results of Test of Significance of Difference in Mean Gain Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Total Sample	230

Table No.	Title	Page No.
29.	Results of Test of Significance of Difference in Mean Gain Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Boys	232
30.	Results of Test of Significance of Difference in Mean Gain Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Girls	234
31.	Results of Levene's Test for Problem solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) – Total Sample, Subsample Boys and Subsample Girls	241
32.	Summary of Analysis of Covariance of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Non-verbal Intelligence as Covariate for Total Sample	243
33.	Results of the Bonferroni's Test of Post Hoc Comparison between the Adjusted Means of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Total Sample	244
34.	Summary of Analysis of Covariance of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Non-verbal Intelligence as Covariate for Subsample Boys	246
35.	Results of the Bonferroni's Test of Post Hoc Comparison between the Adjusted Means of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) – Subsample Boys	247
36.	Summary of Analysis of Covariance of Gain scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Non-verbal Intelligence as Covariate for Subsample Girls	249

Table No.	Title	Page No.
37.	Results of the Bonferroni's Test of Post Hoc Comparison between the Adjusted Means of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) – Subsample Girls	250
38.	Summary of ANCOVA of the Dependent Variables – Total Sample	251
39.	Summary of ANCOVA of the Dependent Variables – Subsample Boys	252
40.	Summary of ANCOVA of the Dependent Variables – Subsample Girls	253

LIST OF FIGURES

Figure No.	Title	Page No.
1.	GeoGebra's Algebra View and Graphics View	66
2.	GeoGebra's Spreadsheet View	66
3.	GeoGebra's CAS View	67
4.	GeoGebra's 3D Graphics View	68
5.	GeoGebra's Probability Calculator View	69
6.	GeoGebra's User Interface	71
7.	GeoGebra's Algebra Perspective	72
8.	Example for a Dynamic Worksheet	75
9.	Bloom's Levels of Cognitive Learning Skills and Intellectual Abilities	83
10.	Pyramidal Structure of Learning Hierarchy by Robert Gagne	84
11.	Graphical Representation of the Phases of the Study	149
12.	Graphical Representation of the Exploratory Phase	150
13.	Graphical Representation of the Developmental Phase	151
14.	Graphical Representation of the Experimentation Phase	151
15.	Graphical Representation of Treatments in Different Phases on both Experimental and Control Group	153
16.	Diagrammatic Representation of the Variables Selected for the Study	156
17.	Phases of ADDIE Model	172
18.	The P-P Plots of the Pretest Scores of the Variables of the Experimental Group for Total Sample	199
19.	The P-P Plots of the Pretest Scores of the Variables of the Control Group for Total Sample	202
20.	The P-P Plots of the Posttest Scores of the Variables of the Experimental Group for Total Sample	205
21.	The P-P Plots of the Posttest Scores of the Variables of the Control Group for Total Sample	208

Figure No.	Title	Page No.
22.	The P-P Plots of the Gain Scores of the Variables of the Experimental Group for Total Sample	211
23.	The P-P Plots of the Gain Scores of the Variables of the Control Group for Total Sample	214
24.	Comparison of Mean Pretest and Posttest Scores on Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of the Experimental Group for Total Sample	217
25	Comparison of Mean Pretest and Posttest Scores on Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) for Subsample Boys	219
26	Comparison of Mean Pretest and Posttest Scores on Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) for Subsample Girls	221
27	Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Total Sample	224
28	Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Boys	226
29	Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Girls	228
30	Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Total Sample	231

Figure No.	Title	Page No.
31	Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Boys	233
32	Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Girls	235
33	The Scatter Plots of the Dependent Variables Against the Covariate for Total Sample	238
34	The Scatter Plots of the Dependent Variables against the Covariate for the Subsample Boys	239
35	The Scatter Plots of the Dependent Variables against the Covariate for the Subsample Girls	240

LIST OF APPENDICES

Appendix No.	Title
I	Problem Solving Ability Test in Geometry (2019)- Malayalam
II	Problem Solving Ability Test in Geometry (2019)- English
III	Sample Lesson Transcript used for Teaching Geometry with Conventional Instructional Strategy- Malayalam
IV	Sample Lesson Transcript Used For Teaching Geometry with Conventional Instructional Strategy-English
V	Sample Lesson Transcript used for Teaching Geometry with Virtual Learning Environment Using Geogebra – Module II
VI	Virtual Learning Environment using Geogebra - Script for Module II (Sample)
VII	Matrix For Evaluating Problem Solving Ability Test
VIII	Response Sheet of Raven's Standard Progressive Matrices
IX	List of Subject and Technology Experts
X	Soft Copy (CD) of the Virtual Learning Environemnt using GeoGebra on Geometry

Chapter **1**

INTRODUCTION

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

INTRODUCTION

Globalization has revolutionized all realm of human livelihood. Every field is facing tremendous changes day by day. The root cause for all these revolutions, i.e. Education too, should be reinvented so as to go abreast with the hand over-fist world. The ways and means of educating and getting educated to be in tandem with the rapid advancements in every sphere, it demands many requisites and skills to survive. In spite of getting knowledgeable, getting skilled is the major objective of education in this competing world. It has been proved that every year scientific knowledge is getting doubled (Nash, 1994). This raised a question in our mind in the beginning of 21st century that, What knowledge and skills our kids require to survive rapid changes apparent in all expanses of life? If we prepare our students for existing prospects, their knowledge and skills will be obsolete by the time they have to use it in the real world (Csapo & Funke, 2017). To endure in the modern world students should acquire 21st century skills like Problem solving ability, creativity, metacognition, innovation etc. Problem solving ability is one of the major fundamental human cognitive process.

In the beginning of 1900s, problem-solving was considered as a machine-driven, methodical, and frequently intellectual or decontextualized set of skills, like those used to crack puzzles or mathematical equations. When the cognitive learning theories emerged, the meaning of problem-solving skill has been changed. Then it is regarded as a complex mental activity comprising of a variety of cognitive skills and activities. Problem-solving encompasses higher order thinking skills like "visualization, association, abstraction, comprehension, manipulation, reasoning, analysis, synthesis, generalization – each needing to be 'managed' and 'coordinated'" (Garofalo & Lester, 1985). In problem solving the brain uses the maximum cognitive functions like analytical thinking, generalization, and synthesis, which involves features such as the scientific way, critical thinking, decision-making, and reflective thinking (Kucukahmet, 1998 & Gursoy, 2006).

Though the significance of developing higher order cognitive skills are very well known to everybody, the education system has not reached yet to integrate a problem solving approach in pedagogy in full swing. Traditional chalk and talk method of teaching never promote cognitive skills such as problem solving ability. Instead of promoting rote learning, meaningful learning couldn't takes place even in the era of constructive approach to teaching learning. So in order to bring a shift from peripheral learning to deep learning, special strategies should be designed and implemented. Current technological revolutions open up wider and innovative opportunities towards bringing change.

As information and communication technology has revolutionized the field of education, it is a universal fact that E-Learning environments can contribute much to the teaching and learning process if the integration is done within the framework of proper pedagogy. E-learning encompasses a range of technologies such as the world wide web, email, chat, new groups and texts, audio and video conferencing delivered over computer networks to impart education enabling the learner to learn at their own pace, according to their own convenience. It is essential to have a great deal of resources and careful planning for effective integration of technology in to education. In this, teachers act as facilitators rather than transmitters of content knowledge, and ICT is regarded as a resource that enhances the learning experience of students. E-Learning has brought back the joy in learning through its innovative and interactive content delivery and has proved to be more appealing among students.

Building customized E-learning programs places high demands on design, programming skills, and time. An alternative to this can be deployment of courses within learning management systems. It also communicates extremely well with many web –based resources (Facebook, YouTube, Wikipedia, JClik, Hot Potatoes, etc.), allowing developers' creativity and versatility. Virtual Learning Environments provide a set of tools that support an inquiry- and discovery-based approach to online learning. Furthermore, it purports to create an environment that allows for collaborative interaction among students as a standalone, or in addition to, conventional classroom instruction.

E-learning environments include interactive activities combining simulations, short videos, virtual experiments, games and more, in order to enhance interactive learning based on constructivism theory, and allow for students and teachers to learn skills for intelligent use of information and technological communication. The environments have been developed in partnership with teachers, as an enhancement to face-to-face teaching, for both curricular and extra-curricular learning. One main advantage of these environments is the freedom of teachers to add, change or use them as is, according to their needs. These environments supply teachers with many interesting tools that can be used to improve the teaching– learning process, and the students to reinforce their abilities and knowledge, in a user friendly and stimulating manner engaging them in a fun, familiar and modern environment where much of their daily non-school activities take place.

Virtual Education and Virtual Learning Environments

Virtual education generally refers to instruction in a learning environment where teacher and student are separated by time or space, or both. The course contents are conveyed through IT applications, multimedia resources, the Internet, videoconferencing, etc. (Dung, 202, pp.45-48). As an innovation to provide education access beyond the campus walls, virtual education gets its origin in 1960, when the University of Illinois created an Intranet for its students. It is the system of linked computer terminals where students could access course materials as well as listen to recorded lectures. Virtual education has grown rapidly and globally in the past few years with diversified online courses at all levels including K-12, colleges, universities and lifelong learning institutions.

There are typically three types of virtual courses depending on the nature of instructional interaction between the teacher and learner, particularly the point of time of occurring interaction. Asynchronous online courses do not take place in real-time. Students are more self-directed, doing the course work and assignments within a time frame. The teacher-student interaction takes place through discussion boards, blogs, and email, etc. There is no appointed class meeting time. Asynchronous are flexible and effective to students with time constraint or busy schedules. Synchronous online courses require the instructor and student to interact online simultaneously. Students receive instruction from teacher and interact with their teacher and course mates through texts, audio chats, and video chats in a virtual classroom. Synchronous learning environments enable students to participate in a course from home in real time. Hybrid online courses, alternatively blended courses, facilitate both in-person and online interaction. Hybrid courses require meeting in-person during a semester and provide for computer-based communication in between those face-to-face sessions. Hybrid type of virtual learning therefore can be both asynchronous and synchronous, and face-to-face interaction

Education and formal training should provide all individuals with competence which leads them to personal accomplishment and development, social inclusion, active citizenship and employment. Among the abilities which should be attained according to the European Commission (2016) are literacy, arithmetic, science and foreign languages, as well as digital competence, business skills, critical thinking, problem solving, learning to learn and financial literacy. Besides, an early command of these skills allows for better forming the complex competencies needed for promoting creativity and innovation which in the long run assure a prosperous life for a person in the workplace as well as in a rapidly changing society.

Education lacks a general consensus on approaches to teaching and learning which would lead to improved performance. There is also the need for joint commitment between educational authorities and teachers. These aspects make it impossible for any effort to innovate, reform or change education to produce a lasting effect on students' academic performance (Bain & Weston, 2012).

The use of technology with educational aims has the potential of increasing deep learning. However, this depends on how it is used for specific purposes. Besides, technology should be integrated into pedagogy in order to make activities more attractive, efficient, technologically generalized and centered on problem solving in real life situations (Fullan & Langworthy, 2013)

The expectative of Information and Communication Technology (ICT) in the area of mathematics, is to design new cognitive measurements with interactive focuses in order to increase the quality of learning and school performance. In this way mathematical formation is formed by way of discovery, evaluation and creation, without discarding conceptual understanding, the development of skills for mathematical processes and their applications (Bravo,2012).

An analysis of 20 studies carried out by Zakaria and Khalid (2016) determined that the benefits of incorporating ICT into teaching mathematics are multiple. Among the advantages of a Virtual Learning Environment (VLE) are: increasing students' interest in learning mathematics, improving academic performance, promoting permanent learning, allowing for positive interactive relations and supporting constructivist learning.

In today's society leaning is permanent, it is not only acquired through formal means, but also in non-formal or informal ways. However, not all students have the skills necessary for autonomous studying and therefore we must promote the development of these skills so that students can attain the knowledge they need. Self-regulated learning, self-evaluation and actions for modifying study habits promote students' active and critical participation in decision-making related to their education, which will result in the formation of more meaningful environments (Cabero, 2013).

Virtual learning is a process of personal reconstruction of a content which is carried out in function of and based on the cognitive structure of learning. Among the elements which make up this structure are basic cognitive skills, specific knowledge of an area, learning strategies, meta-cognitive abilities and self-regulation, affective and motivational factors goals and expectations. All of these elements and the way a student utilizes them can lead to quality learning (Onrubia, 2016).

The change of paradigm represented by virtual learning is not only a change for students but also for all of those involved in the educational system. This is why teachers, administrators, technical and support staff as well as the institution itself find themselves faced with a new and different form of teaching-learning in which the ambit is no longer a closed system such as a classroom. In order to work for various kinds of students, the development of VLE requires an effort of migrating from a closed system to a new reality. This demands constant up-dating of subjects which arise related to virtual learning in order to incorporate them during the design of VLEs (Khan, 2016).

The challenge in virtual learning as in any other teaching system is to achieve efficacy. This is achieved when lessons which are compatible with the processes of human learning are developed. Moreover, it must be taken into account that ICT has the ability to provide much more sensorial data than a person's nervous system can assimilate. Learning may decrease if the audio and visual elements used in a lesson interfere with human cognition (Clark & Mayer, 2016).

Virtual leaning environments should be spaces for teaching and producing learning which are pedagogically modeled and integrated with various components such as: technological platform, activities and material, which all together have the objective of generating learning. In turn, interaction of the community by way of technological tools enriches the quality of learning (Silva, 2011).

Generally speaking according to Clark and Mayer (2016) the VLE should have one or more of the following characteristics: students can control their progress throughout a lesson; the methods for achieving commitment create adequate psychological processing; the graphs and vocabulary in each lesson correspond to the level of learning maturity of the student; realistic settings are used to create the learning context.

In the teaching of mathematics a VLE is a means by which ICT facilitates pedagogical communication between the teacher and the student during the teaching-learning process, promoting the self-construction of the educable subject. The design of a VLE should include these five aspects: knowledge (design of interactive digital content with pedagogical perspective), collaboration (student-

student, student-teacher and teacher-teacher interaction), consulting (both synchronous and asynchronous), experimentation (simulation) and management (homework, evaluation and follow-up), all of this in order for technology to stimulate the required learning (Bravo, 2012).

Problem Solving Ability

Problem-solving skill is defined as a person's ability to engage in cognitive processes when understanding and solving problems for which the method of solving is not readily available. Problem-solving skill is one of the important skills because, in addition to developing thinking skills, it also trains students' ability to manage learning to develop thinking skills. Attempts have been made to develop students' problem-solving skills through the development of learning models, such as problem-based learning and problem-solving models. The difficulty of students in solving problems is due to their tendency to question things that are low-level factual rather than analyzing abstract things, it is difficult to consider systematic evidence in formulating arguments, and are proficient to carry out a procedure but lack of providing reasons why it should be.

Problem solving plays a crucial role in the learning of mathematics. Typically the process of problem solving combines knowledge and heuristics with specific strategies for collecting, organizing and treating information, making use of different representations, mathematical models and conversions from one language to another and establishing relationships between the learned contents.

Many of the determining factors of problem solving skills are related to cognitive processes. It is obvious that to be successful in the solving of mathematical problems a student must be able to understand and interpret the mathematical relationships involved; but, an effective resolution of the problem is also dependent upon the student's knowledge of specific situations, i.e. of its contents and the way the student organizes his/her knowledge for that particular situation and the specific strategies corresponding to those contents. Authors such as Hinsley, Hayes and Simon have provided evidence to show that those who are competent in the solving of mathematical problems have a wide knowledge of problems type and the specific strategies required to solve them. The choice of a specific strategy for solving problems according to its specific contents is not incompatible with the general strategies. On the contrary, specific strategies arise naturally within any general strategy.

Problem Solving Ability and Geometry

A significant part of mathematics, geometry is a domain where the features and traits of different shapes, sizes, diagrams, angles, positions, etc are studied and defined for the understanding of the academicians and students. It is an important part of mathematics that has been used in other subjects as well. Its existence can be tracked down to thousands of years back during the Egyptian civilization. The Indus Valley Civilization also showed the existence and use of geometry. They were the first to find and use the properties of obtuse triangles. Since the 6th Century BCE, the Greeks refined the concepts of geometry exponentially.

The natives of this civilization researched and found the existence of different types of shapes in nature. They also invented a few and found that the four-sided pyramid is extremely stable. A pyramid took decades to complete but is standing the test of time amidst an arid desert for thousands of years. If you observe very carefully, you will find the best examples of geometry in our daily life.

Geometry, as one of the most important branches of Mathematics, has a very significant place in education. Most of the items that we mostly see and use in our environment are composed of geometrical shapes and objects. Utilizing these objects and shapes efficiently depends on understanding the relations among them. We also make use of geometrical thoughts in solving problems (like painting, liningwall etc.), in defining the space and running our profession as well. Geometrical shapes and objects are a part of our jobs and works. Making effective use of these objects depends on defining them and understanding the relation between the object and its duty (Altun, 2004:217). The subjects in geometry are the ones that firstly draw attention of the people. The requirement to divide a piece of surface properly gave birth to geometry which is the information of measurement of objects and shapes and expression by the numbers. That's why this course has direct place in people's daily lives (Fidan, 1986). Geometry is area of study of mathematics dealing with shapes and space. This area of study has an important role in developing students' critical thinking and problem solving skills (Pesen, 2006). Students start to understand and express the world around them by means of geometry and they analyze and solve the problems. They can also express from the perspective of the shapes to understand the abstract symbols better.

The first inspiration sources of the mathematics phenomenon are the nature and the life. It is more required and easier to relate its geometrical side of this phenomenon. What people have done on behalf of geometry is to see the existing and undeniable truths in the nature and to take these relations to the new truths and new relations by discovering the relations among them (Develi & Orbay, 2003). People make decisions in their works and jobs by depending on their information regarding geometric shapes and objects. Carpenters measure the angles for house building. Engineers decide on which angles will shape the slope of a highway road. Gardeners plan the geographical formations and positions on which flowers are grown (MEB, 1999:1-3). The following items can be among some reasons why geometry is given place in mathematics teaching at schools (Baykul, 2005:363).

1) Critical thinking and problem solving occupy an important role amongst mathematical studies at school. Geometry studies provide significant contribution to the skills of critical thinking and problem solving.

2) Geometry subjects give assistance in teaching other topics of the mathematics. For instance, geometry is utilized to gain the concepts regarding fraction and decimal numbers; rectangles, squares, areas and circles are mainly used to teach the techniques of the operations.

3) Geometry is one of the most important parts of the mathematics which is used in daily life. For example, the shapes of the rooms, buildings and shapes used for ornaments are geometric shapes

4) Geometry is a device which is used a lot in science and art as well. As an illustration, it can be said that architects and engineers use geometric shapes a lot; geometrical characteristics are used quite much in the physics and chemistry.

5) Geometry helps students gain much more awareness about the world in which they live and appreciate its value. For example, the shapes of crystals and the orbits of the space objects are geometric.

6) Geometry is a tool that will help students have fun and even make them love mathematics. For example, they can have enjoyable games with geometrical shapes through cutting, pasting, rotating, parallel displacement and symmetry.

It is required that a person who will be in charge of teaching and training of students must have comprehensive knowledge of the subject and must know the growth and development of human closely. Geometry is one of the primary courses which are difficult to learn and comprehend for students. It is a fact that the success level in geometry is low. As a result of this, mathematics and geometry is a nightmare for most of the students (Akın & Cancan, 2007) because mathematics is a system on its own.

It has been widely recognized that problem-solving activities are crucial in developing and learning mathematics. Indeed, it is common to structure and frame both mathematical curriculum and learning environments through problem-solving activities. Currently, significant developments of digital technologies are shaping both students' social interaction and ways of learning mathematics and solving problems. The use of a Dynamic Geometry System like Geogebra provides affordances to develop a geometric reasoning as a mean to work and solve mathematical problems. In this process, it becomes important to think of and represent problem statements and concepts geometrically, to construct dynamic models of problems, to trace and examine loci of particular objects, to analyse particular and general cases, and to communicate results.

Here the researcher through the study intends to design a course using Geogebra in geometry for secondary school students and it is presented over Virtual Learning Environment and in the conventional mode. Later the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in geometry are analysed.

Need and Significance of the Study

In the past, students followed a mechanical progression in education. Every year posed new challenges and concepts for them as they undertook a standardized, one-size-fits-all curriculum and examinations. Education was concerned with getting the correct answer and scoring high grades, to reach the next level. There was little room for out of the box thinking that considered innovative solutions. The more information students could retain and regurgitate, the better equipped they were for an exam, ultimately translating to their real-life success. As a result, students were kept astray from practical skills and complex real-world problems they would eventually face after finishing their formative years in school and college. This situation demands immediate intervention in the development of the higher order skills like problem solving ability students.

In the era of technological revolution, the opportunities brought by ICT are very high. As the volume of knowledge, learning opportunities are multiplied manifold enrichment of cognitive skill are too a major advantage of electronic learning environments. The benefits of virtual education are varied for all stakeholders including the course provider, the instructors, and the learner. Virtual learning and teaching application can obviously diversify the delivery methods, therefore enriching the teaching experiences for the faculty. Fast changing IT technology constantly urges the teacher to learn new tools and applications to enrich both the contents and the educational activities of their lessons. As for the students, virtual education is widely appreciated for its flexibility, cost effectiveness, and convenient access. With asynchronous courses, the student can enjoy a more flexible schedule that conveniently fits their available time and location.

So making use of those virtual learning environments are the need of the hour.

Reddy (1992) in his investigation on teaching theorems in Geometry in secondary schools found that the teachers are not adequately equipped to teach theoretical Geometry effectively. He suggested that the teachers must be provided with some orientation programs related to the teaching of Geometry so that they can teach Geometry in the class with effectiveness and impart more knowledge to students. This will definitely create interest in students and motivate them to learn the subject and do justice to Geometry in the examinations.

Murthy's investigation in 1971 (as cited in Chithra, 2017) into the techniques of teaching theoretical Geometry to slow learners at eighth standard level based on the nature of their drawbacks arrived at the following conclusions.

- Slow learning arises from the difficulties in the attainment of four instructional aims of teaching Geometry- a) Mastery over fundamental concepts, b) Reasoning capacity, c) Related thinking, and d) Skill in application.

- Many teachers fail to employ relevant techniques of teaching Geometry
- Teaching of Geometry is mostly prosaic, bookish and narrative.
- Teachers generally fail to use relevant auxiliary techniques like diagnostic tests or other follow-up programmes, with the specific intention of effectively improving the four major objectives of teaching Geometry.
- Students are becoming slow learners mostly because of ineffective teaching.
- The teachers seem to have good intentions to improve the process of learning Geometry, but they do not seem to be exerting themselves so as to plan and arrange their work to achieve the goal in all its dimensions.

The rudiments of this major branch of Mathematics are easily understood by secondary school students who have good spatial intelligence, whereas those students who have inadequate conceptual clarity in Geometry find it difficult to solve problems related to the topic. When the currently used teaching techniques are inadequate, other techniques like Laboratory Approach, Computer Assisted Instruction and Multimedia Approach have to be experimented so as to enable students to effectively solve problems in Geometry.

Unfortunately, school Geometry curricula have, until very recently, included very few of the right kinds of experiences. Elementary and middle school Geometry curricula have included too many low-level experiences in which students are simply asked to learn names of shapes and other geometric objects. Then, in high school, students are expected to learn geometric reasoning as they work with proofs. The typical elementary school curriculum keeps students at a low level of development, and then the high school curriculum unreasonably expects students to jump to a high level of development. For most people, this jump is impossible, and their development of geometric thinking is thwarted. Geometric thinking assisted by technology can be used for better learning of the subject. Teachers need to modify their approach and it is logical to use strategies like Virtual Learning environment in teaching topics like Geometry to a group of students in which many of them may not be good in both these abilities.

All these factors were raised many questions to the mind of the investigator, to think that the current study is very significant and need of the hour.

Statement of the Problem

The present study intends to develop an Instructional Strategy, Virtual Learning Environment using Geogebra in Geometry for Secondary School Students and to study its effect on Problem Solving Ability. Hence the study is entitled as **"Effect of Virtual Learning Environment Using Geogebra on Problem Solving Ability in Geometry of Secondary School Students.**

Definition of the Key Terms

The key terms used for the study have been operationally defined below.

Virtual Learning Environment

A Virtual Learning Environment (VLE) is a set of teaching and learning tools designed to enhance a student's learning experience by including computers and the internet in the learning process. (TechTarget.com, 2011)

In this study Virtual Learning Environment refers to an Instructional strategy in a digital platform with simulations, Virtual experiments, animated videos, interactive quizzes etc. to teach geometry.

Geogebra Applets on geometry are the major element of this Instructional strategy.

Geogebra

An open-source dynamic mathematics software designed by Markus Hohenwarter as an open-source dynamic mathematics software that incorporates geometry, algebra and calculus into a single, open-source, user-friendly package (Hohenwarter et al., 2008).

Problem Solving Ability

Anderson, 1980 defines Problem Solving Ability as any goal directed sequence of cognitive operations.

Praveen, 2014 defines Problem Solving Ability as the cognitive capability of the problem solver to perform physical or mental operations based upon his/her knowledge so as to achieve the goal of solving a problem.

In this study Problem Solving Ability is defined as the Cognitive ability to Understand the problem, Map the problem, identify relationships in the problem and finding the solution to geometric problems of grade 9 mathematics following state syllabus in Kerala.

Geometry

Geometry may be defined as the branch of mathematics concerned with the properties and relations of points, lines, surfaces, solids, and higher dimensional analogues. (Oxford Concise Dictionary of Mathematics, 2020)

In this study Geometry refers to the content portions dealing with 'Prisms' in the Mathematics text book of grade IX of secondary School curriculum dev eloped by SCERT, Kerala.

Secondary School Students

In the present study secondary school students means the students studying in grade 9 in the Schools in Kerala following SCERT curriculum.

Variables of the Study

The study has been designed to find out effect of virtual learning environment with Geogebra on problem solving ability in geometry of secondary school students. The study involves two types of variables viz, independent variable and dependent variable. **The independent variable** in the study is instructional strategy that the investigator administrated in two groups of participants viz, experimental group in which Virtual Learning Environment using Geogebra was used and control group which was instructed according to conventional instructional strategy. **Dependent Variable** of the study is Problem Solving Ability in Geometry which has the following Components:

- Understanding the Problem
- Mapping the Problem
- Identifying relationships
- Finding the Solution

Control variable: Statistical equalization of both experimental and control group was done using ANCOVA by taking Non-verbal intelligence of the participants as covariate.

Objectives of the study

The objectives set for the study are following,

General Objectives

1. To develop a Virtual Learning Environment using Geogebra on geometry for secondary school students.
2. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School students

Specific Objectives

1. To find out the effect of Virtual Learning Environment using Geogebra on first component of Problem Solving Ability (Understanding the Problem) in Geometry of Secondary School students for the total group and subgroups based on gender.

2. To find out the effect of Virtual Learning Environment using Geogebra on second component of Problem Solving Ability (Mapping the Problem) in Geometry of Secondary School students for the total group and subgroups based on gender.
3. To find out the effect of Virtual Learning Environment using Geogebra on third component of Problem Solving Ability (Identifying relationships) in Geometry of Secondary School students for the total group and subgroups based on gender.
4. To find out the effect of Virtual Learning Environment using Geogebra on fourth component of Problem Solving Ability (Finding solution to the problem) in Geometry of Secondary School students for the total group and subgroups based on gender.
5. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability (Total) in Geometry of Secondary School students for the total group and subgroups based on gender.
6. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on first component of Problem Solving Ability (Understanding the Problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
7. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on second component of Problem Solving Ability (Mapping the Problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
8. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate,

on third component of Problem Solving Ability (Identifying relationships) in geometry of Secondary School Students for the group and subgroups based on gender.

9. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on fourth component of Problem Solving Ability (Finding solution to the problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
10. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on Problem Solving Ability (Total) in geometry of Secondary School Students for the total group and subgroups based on gender.

Hypotheses of the Study

Based on the objectives given above, the following hypotheses were formulated.

1. Virtual Learning Environment using Geogebra has significant effect on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender
2. Virtual Learning Environment using Geogebra has significant effect on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender
3. Virtual Learning Environment using Geogebra has significant effect on ability to Identify Relationships in the problem in Geometry of Secondary School Students for the total group and subgroups based on gender

4. Virtual Learning Environment using Geogebra has significant effect on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender
5. Virtual Learning Environment using Geogebra has significant effect on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender
6. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
7. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
8. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Identify Relationships in the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
9. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

10. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Methodology

The study intended to find out the effect of the Instructional Strategy, Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students, adopted Experimental method.

Design of the Study

The design selected for the study was Quasi experimental Pre-test Post-test Non-equivalent group design.

Experimental group → O_1 X O_2

Control group → O_3 C O_4

Where,

O_1 & O_3 are Pre-Tests

O_2& O_4 are Post-Tests

X – Exposure to Experimental Treatment

C – Exposure to Control Treatment

For the present study two intact classes of IX standard students of Al-Anvar School in Malappuram District of Kerala has been selected. One group was selected as experimental and the other as control group. At the beginning of the experimentation Pretest on Problem Solving ability in Geometry has been administered on both experimental and control groups. To test the Nonverbal intelligence of subjects, the investigator administered Standard Progressive Matrices Test prepared by JC Raven. Afterwards, Experimental group has been treated with Virtual Learning Environment using Geogebra for learning Geometry prescribed in the curriculum. For the control group, conventional method of teaching has been carried out to teach geometry.

After completion of the treatment with Virtual Learning Environment using Geogebra in geometry in experimental group and conventional method of teaching in control group, a post test on Problem solving ability has been carried out on both groups.

Participants

The population for the study is secondary school students of Kerala state. Two intact Ninth Standard classes of Al-Anvar High School, Kuniyil, Malappuram was selected for the study for minimizing the effects of School environment on experimentation. Final samples for the study were 90 after deducting the damaged samples. The experimental group contained 44 students and There was 46 students in the control group

Instruments Used

The investigator used of the following tools for the study

- Instructional strategy, Virtual Learning Environment using Geogebra (Rishad & Praveen, 2019)
- Problem Solving Ability Test (Rishad & Praveen, 2019)
- Standard Progressive Matrices (Raven, 1958)
- Lesson Transcripts on conventional instructional strategy (Rishad & Praveen, 2019)

Statistical techniques Used

The investigator used the following statistical techniques for the study,

- Descriptive statistics
- Test of significant difference between mean scores

- ANCOVA (analysis of covariance).
- Bonferroni Test for post hoc comparison

Scope of the Study

The study has been designed to investigate effect of virtual learning environment using Geogebra on problem solving ability in geometry of secondary school students. An instructional strategy based on virtual learning environment using Geogebra as its major element was developed which can effectively be used to teach geometry in mathematics. The influence of gender on problem solving ability was investigated. Data were analyzied by using appropriate statistical techniques and the results can be generalized.

Delimitations of the Study

Even though the present study was conducted with maximum possible care, certain element which could hardly be avoided, have crept in to the study, they are

- The topic selected was limited to a unit in geometry of 9th standard Mathematics syllabus as per SCERT curriculum in the state of Kerala
- Shortage of time has necessitated the investigator to limit the study to one dependent variable which is Problem solving ability in geometry
- In this study two intact classroom were selected as experimental and control groups instead of randomised matching groups. However the differences were statistically accounted using ANCOVA.
- Due to infrastructural limitations, every student could not be provided with a computer, a pair of three were asked to share a computer for learning with Virtual Learning Environment using Geogebra.
- The investigator could use only Nonverbal intelligence as control variable.

Organization of the Report

The report of the study is organized in six chapters. The details given in each chapter are as follows.

Chapter I presents a concise introduction of the problem, need and significance of the study, statement of the problem, definition of key terms used in the title, variables of the study, objectives set for the study and the hypotheses formulated, a brief description of methodology, scope and limitations of the study.

Chapter II It has two parts. The first part presents the theoretical overview of the variables in the present study. Second part deals with studies reviewed and observations of other researchers related to the variables.

Chapter III includes the methodology of the study in detail. It mention detailed description of design, sample, methods and materials of data collection, data collection procedure and statistical techniques used for analysis of collected data.

Chapter IV deals with the statistical analysis of the data, interpretations and discussions of results.

Chapter V contains summary of the study, major findings, tenability of hypotheses and conclusions arrived at.

Chapter VI presents a detailed description of educational implications of the study and recommendations for further research.

Chapter **2**

REVIEW OF RELATED LITERATURE

- ***Theoretical Overview of the variables***
  - ***Virtual Learning Environment***
  - ***Geogebra***
  - ***Problem Solving Ability***
- ***Review of Related Literature Studies***
  - ***Virtual Learning Environment***
  - ***Geogebra***
  - ***Problem Solving Ability***

REVIEW OF RELATED LITERATURE

The present chapter is an earnest attempt to analyse the theoretical framework of variables involved in the study. Attempts were also made to analyse the researches using these variables in educational settings. Hence this chapter has been divided into two sections. The first section deals with theoretical background and the second section deals with the empirical studies connected with the variables under consideration. The chapter organises its heading in the following manner

Theoretical Overview of the variables

- Virtual Learning Environment
- Geogebra
- Problem Solving Ability

Review of Related Literature Studies

- Virtual Learning Environment
- Geogebra
- Problem Solving Ability

Theoretical Overview of the Variables

Theoretical overview of the Independent Variables namely Virtual Learning Environment, Geogebra, and Problem Solving Ability is presented in this section.

Virtual Learning Environment

Virtual learning is usually associated with online courses or online environments, but it has much broader dimensions. The different theoretical aspects of learning and teaching process in virtual learning are explored in the following section.

Meaning, Definition and Related Terms

Virtual Learning: Meaning and Definition

Virtual learning is a learning experience that is enhanced through utilizing computers and/or the internet both outside and inside the facilities of the educational organization. The instruction most commonly takes place in an online environment. The teaching activities are carried out online whereby the teacher and learners are physically separated (in terms of place, time, or both).

Virtual learning is a distance learning conducted in a virtual learning environment with electronic study content designed for self-paced (asynchronous) or live web-conferencing (synchronous) online teaching and tutoring.

Virtual learning is defined as learning that can functionally and effectively occur in the absence of traditional classroom environments (Simonson & Schlosser, 2006).

E-learning systems, or VLEs (Virtual learning environments), are rapidly becoming an integral part of the teaching and learning process. VLEs in OER (Open Education Resources) present a number of opportunities to students such as enhancing their learning skills, learning more than the things offered in the face-to-face teaching. It improves communication efficiency, both between student and teacher, as well as among students (Martins & Kellerman, 2004). A VLE is a web based communication platform that allows, students, without limitation of time and space, to access different learning tools, such as programmed information, course content, teacher assistance, group discussion, document sharing systems, and learning resources (Martins & Kellermanns, 2004; Ngai et al., in press).

Virtual Learning: Related Terms. Virtual learning has many forms and related terms. These seem very similar but represent different aspects of learning and teaching and can help us understand the essence of "virtual learning." Here are the most commonly used ones:

- ***E-learning.*** E-learning in its broadest sense refers to **using electronic technologies for learning and teaching.** The learning activities take place either entirely or partially online. They can be conducted by means of electronic media without the use of the Internet.

- ***Web-based Learning.*** Web-based learning refers to the use of a web browser for learning.

- ***Online Learning.*** Online learning is associated with the provision of electronic content available on a computer/mobile device. It might involve the use of the internet, but the use of a web browser is optional. Online learning can be done through programs or apps installed on your personal device, which can also be used offline.

- ***Distance Learning.*** Distance learning does not have to use electronic and web-based technologies. It means learning from a distance; in other words, the participants are physically separated. Distance learning is related to providing instruction to a person who is learning in a place and at a time different from that of the teachers and the other learners. Nowadays, with the development of digital technologies, distance learning is increasingly associated with online learning. The use of virtual classrooms for live online teaching brings distance learning closer to the traditional form of learning by reproducing its main characteristics in the online environment.

• ***Blended Learning.*** This type of learning combines virtual and traditional forms of teaching. The learning content should be digitalized and made available online. Thus, learners are able to control the learning process in terms of time, place, tempo, and method of learning.

Different Forms of Virtual Learning

The emerging education paradigm "virtual learning" has the potential to improve student achievement, educational access and schools' cost-effectiveness. Specifically, virtual learning uses computer software, the Internet or both to deliver instruction to students. This minimizes or eliminates the need for teachers and students to share a classroom. Virtual learning does not include the increasing use of e-mail or online forums to help teachers better communicate with students and parents about coursework and student progress; as helpful as these learning management systems are, they do not change how students are taught. Virtual learning comes in several forms. They are

• **Computer-Based.** Instruction is not provided by a teacher; instead, instruction is provided by software installed on a local computer or server. This software can frequently customize the material to suit the specific needs of each student.

• **Internet-Based.** This is similar to computer-based instruction, but in this case, the software that provides the instruction is delivered through the Web and stored on a remote server.

• **Remote Teacher Online.** Instruction is provided by a teacher, but that teacher is not physically present with the student. Instead, the teacher interacts with the student via the Internet, through such media as online video, online forums, e-mail and instant messaging.

• **Blended Learning.** This combines traditional face-to-face instruction, directed by a teacher, with computer-based, Internet-based or remote teacher online instruction. In effect, instruction comes from two sources. a traditional classroom teacher, and at least one of the forms of virtual learning described above.

• **Facilitated Virtual Learning**. This is computer-based, Internet-based or remote teacher online instruction that is supplemented by a human "facilitator." This facilitator does not direct the student's instruction, but rather assists the student's learning process by providing tutoring or additional supervision. The facilitator may be present with the learner or communicating remotely via the Web or other forms of electronic communication.

Similar forms of virtual learning are sometimes grouped into broader categories.

• **Online Learning.** This is any form of instruction that takes place over the Internet. It includes Internet-based instruction; remote teacher online instruction; and blended learning and facilitated virtual learning that involves these two virtual learning methods. It excludes computer-based learning.

• **Full-Time Online**. This is online learning with no regular face-to-face instruction or facilitation. It is Internet-based and remote teacher online learning only, though it may include some occasional interaction with human teachers and facilitators. Online learning has become increasingly popular in primary and secondary schooling over the last decade.

Distributed Virtual Learning System

There are three different types of distributed Virtual learning systems. a) The Broadcast model, b) The online model c) The collaborative distributed model

a) **Broadcast VLS Model.** Is typically fashioned after a lecture-style classroom environment, in which the instructor and students are located at two or more remote locations. Sound, full-motion video, and presentation material are transmitted from a central location (classroom or studio) to remote locations. Popular examples of this model includes courses delivered through videoconferencing, cable or satellite transmission (e.g. instructional T.V). In this VLS model, the instructor is viewed as the primary source of knowledge, controlling content and the rate of information transmission to students .In this distributed VLS model, the predominant pedagogical approach remains the conventional "chalk and talk" method commonly found in more traditional face-to-face classroom environment. The vision of VLS is primarily that of automation and efficiency gains. Information flow (mostly in the form of lectures and presentation materials) between the instructors and remote students are automated, efficiency gains involve cost savings in the form of time and resources otherwise spend on traveling. In some cases, this predominantly one-way broadcast model may be combined with direct synchronous and/or asynchronous communication links between the instructors and each remote student. These links serve to facilitate communication of students' feedback and questions to the instructor. IT used in these environments include—telephone or online chat facilities and key response pads offer (synchronous communication.) to e-mail (asynchronous communication). Use of synchronous communication devices creates some degree of interactivity in the VLE; it provides the instructor with useful feedback to gauge students' comprehension, and thus allows the instructor to adjust the presentation of materials accordingly. Similarly, the use of asynchronous communication devices (e.g. e-mail) between the instructor and students facilitates student feedback and allows the instructor to answer questions beyond the scheduled class period.

b) Online VLS Model. In this model, remote students (using ICTs) gain access to course content and learning resources such as simulations, computer-based exercises, demonstrations, and hypertext based study guides. Here the student is largely in charge of his or her learning thus providing greater flexibility in choosing the time, pace, frequency and form of learning activities. This approach to VL increases in prevalence as more interactive multimedia learning resources are made available by educational publishers via CD and other resources on the www .Unlike the broadcast VLS model, which treats learning as passive receivers of pre-packaged information transmitted by the instructors, the online distributed learning model views the students as proactive in interpreting and constructive meaning from information by processing and filtering it through their existing cognitive structures. The role of IT in the online VLS model is to provide learners with the capabilities to access and manipulate learning materials in order to form new understandings and to create new knowledge. For e.g. many VLS provide capabilities for analyzing, synthesizing, filtering and summarizing information through simulation models.

c) Collaborative Distributed VLS Model. In the collaborative distributed VLS model, students create knowledge and understanding primarily through social interactions across time and /or geographical distance through the use of Information and Communication Technologies, such as E-mail and online chat facilities. In the collaborative distributed VLS, learning occurs from the opportunity of the group member to be exposed to each others thinking, opinions and beliefs, while also obtaining and providing feedback for clarification and comprehension.

The three distributed VLS models described here represents the pure forms, it is quite likely that in a distributed learning programme, more and one of the models would be use.

Historical Development of Virtual Learning Environment

Early e-learning systems, based on Computer-Based Learning/Training often attempted to replicate autocratic teaching styles whereby the role of the e-learning system was assumed to before transferring knowledge, as opposed to systems developed later based on Computer Supported Collaborative Learning (CSCL), a pedagogical approach where in learning takes place via social interaction using a computer or through the internet. This kind of learning is characterized by the sharing and construction of knowledge among participants using technology as their primary means of communication or as a common resource, which encouraged the shared development of knowledge.

Virtual learning environment also referred to as Learning Management System creates a well-made environment to assist teachers and management of educational resources for their students using computers and softwares. During the early stages of using Computers in education, E-learning was termed as, Computer-Based Instruction (CBI), "Computer Assisted Instruction" (CAI), Computer Based Training (CBT), Computer Managed Instruction (CMI), Course Management System (CMS), Integrated Learning Systems (ILS), Interactive Multimedia Instruction (IMI), Learning Management System (LMS), Massive open online course (MOOC), On Demand Training (ODT), Technology Based Learning (TBL), Technology Enhanced Learning (TEL),Web Based Training (WBT) and Integrated Learning Systems (ILS). The various milestones in the development of VLE are discussed below.

Rosenblatt (1957) invented a learning machine at the Cornell Aeronautical Laboratory, which attempts to know human memory, learning and cognitive process.

Programmed Logic for Automated Teaching Operations (PLATO, 1960) system developed at University of Illinois, Urbana-Champaign delivers and manages course content over Internet. The features of PLATO system include instructors could inspect student's improvement data, as well as communicate and managing the lessons themselves and an author can communicate and produce new lessons.

In the early 1960s, Stanford university psychology professors Suppes and Atkinson experimented with using computers to teach math and reading to young children in elementary schools in East Palo Alto, California. Stanford's Education Program for Gifted Youth is descended from those early experiments.

Engelbart (1962) published his work on "Augmenting Human Intellect: A conceptual Framework". He projected the usage of computers to enhancement training. He started to develop a system to expand human abilities and he called this system as TheoN-Line System (NLS).

In 1963, Luskin installed the first computer in a community college for instruction, working with Stanford and others, developed computer assisted instruction. The PLATO compiler developed in 1960 allowed to develop a variety of forms of teaching logics for different fields, varying from mathematics to behavioral sciences. The Altoona Area School District in Pennsylvania started to use computers to coach students. The PLATO, 1965 shows some of the new features of E-learning techniques. Those include that, the system could teach to thousands of learners at a time, and each student can continue through the materials independently. There are two types of teaching methods in PLATO system. They are tutorial logic and electronic book. Where, the system presented information with different example, then asked questions on presented materials and inquiry logic where the student can request and organize suitable information from the computer. The presentation materials (slide selector) called as electronic book. The stored information in the system is called as an electronic blackboard.

Department of Defense Commissions (ARPSNET) (1969) in US and the Department broadcasted 12 Stanford engineering courses on two channels via the Stanford Instructional Television Network (SITN) by Stanford University. The first Associate committee on Instructional Technology has formed at the National Research Council of Canada. The seven-year project named as Project Solo (student) or Soloworks in Pittsburg, USA. In this, the student has the controlled, individualized use of computers in education. At the same time, restrictions were also recognized, and the group ended up proposing a “Community of Learning” model in 1979.

Havering (1970) developed Computer Managed Learning System in London. By 1980, so many students used this and hundreds of teachers used in their applications, including science and technology, remedial mathematics, carrier guidance and industrial training.

Suppes (1972), Professor of Stanford University developed computer- based course in logic and set theory. This offered for Stanford undergraduates from 1972 to 1992. The learning research group was formed at Xerox PARC in Palo Alto", California. Alan Kay advanced an idea of Graphical User Interface (GUI) by inventing icons for folders, menus and overlapping Widows. Kay and his group envisioned a computer for teaching and learning that they called the “KiddiKomputer,” and programmed by using the Small talk language.

National Development Program (1973) organized a computer-assisted learning program and setup in UK. The report of the program includes Drill, skill practice, programmed and dialog tutorials, testing and diagnosis, simulation, gaming, information processing, problem solving, computation model, construction, graphic display, management of instructional resources, presentation and display of materials. The Trinity University in Texas maintained 1500 variables like, all students academic and personal data, all faculties' data that dealt with courses and teaching, all course data in regards to student, faculty and class meeting times and days, enrollments, building and college calendar and catalog. This is also called as an interaction course management system.

Jay Warner, Carnegie of Mellon University wrote a CAI (Computer-Assisted Instruction) module. He used some of the principles and written the module in FORTRAN IV.

Turoff (1974) founded the computerized conferencing and communications center at New Jersey Institute of Technology (NJIT) and conducted research on Computer-Mediated Communication (CMC). Much of this is on its applicability of "Virtual Classroom", including field trials in the 1980s. On June 1974, the first computer magazine launched for general readers and hobbyists.

COMIT (1975) was a complicated system of Computer-Assisted Instruction developed jointly by IBM and University of Michigan in 1976 - Waterloo in Canada. This emphasized the audio-visual capabilities of Television set and light pens. The University of Michigan developed Michigan Terminal System (MTS), a computer time-sharing operating system where, a program called CONFER was developed by Robert Parnes and gave its capabilities for computer conferencing.

Edutech Project of Encinitas (1976) -California (Digital ChoreoGraphics of Newport Beach, CA) developed DOTTIE, a TV set-top device linking the home TV for online services such as CompuServ and source via common household telephone. The development of Language Pop 11 and its teaching tools were started at the University of Sussex. The development of KOM computer conferencing system began at Stockholm University. The first experimental Open University of

Cyclops system was then called as Telewriting or audio-graphic system. Nowadays it is called as Whiteboard system. Initially a team was focusing on storage cassette tape of digital data to drive VDU and secondly, handwriting over telephonelines.

Zinn at the University of Michigan described about computer-based conferencing, seminars, communities, curriculum development and proposal preparation. Coastline community College launched the college beyond walls. This was the first community college launched with no college grounds, and gave importance to Telecourses and community facilities. Bernard Luskin was the founder of college, he coined the slogan as “the community is the campus, the citizens are the students.”

Ontario (1977) pioneered the use of satellites for educational teleconferencing and direct-to-home transmission through the herms project with the help of Canadian Federal Department of Communications. The experiments conducted via electronic classrooms between students of Toronoto and California. The Open University of UK introduced the software and hardware teams and developed Telewriting systems.

Pathlore (1978) started to develop CBT solutions. In 1995, it became popular its PHOENIX software delivered “Virtual Classrooms” to several corporate networks. National Science Foundation released its evaluation version of MITRE TICCIT and used the computer television system as a primary source of instruction for English and Algebra.

Successmaker (1980) introduced K-12 learning management system with an importance on reading, spelling and numeracy. The Open University began a pilot experiment of a view data (videotex) system OPTEL, on a DEC20 mainframe. In 1980, TLM (The Learning Management) was released the learning manager to streamline different roles for students, teachers, educational assistants and the administrators. The system had a complicated test bank capability, generated tests and practice activities based on learning objects data structure, Instructors and students or post messages. Originally, it is called as LMS (Learning Management System). TLMwas used widely at SAIT (Southern Alberta Institute of Technology) located in Alberta, Canada.

School of Management and Strategic studies started at the Western Behavioral Sciences Institute in Jolla (1981). California started an online program. Over a period, Open University has also developed its own system to view data (videotex) and called it as OPTEL. In addition to this, other systems also implemented as VOS (Videotex Operating System) allowed to display and manipulation of text files via videotex. VOS was further, developed into a tele software used in commercial development for IMS, the media research company (using a very precursor of Web/CGI development). The Computer Assisted Learning Center (CALC) (1982) founded as a small, offline computer based adult learning center.

McConnell and Sharples (1983), introduced a distance teaching by Cyclops: an educational evaluation of the Open University telewriting system. In the courseware authoring tools developed at Stanford University (1984) a number of teaching applications were created, including tutorials of economics, drama simulations, thermodynamics lessons, historical and anthropological role-playing games. The Graduate School of Computer and information sciences, at Nova Southeastern University (1985), pioneers recognized graduate degrees through online courses, awarding the first doctorate.

NKI (1987), developed LMS, started distance education in Norway, and offered Online distance education courses, through EKKO. During this year, Authorware Inc, formed in Minnepolis, St. Paul, developed, a Macintosh based authoring system called “course of action.” Author ware was the first and most extensively used platform as per industry standard.

Berners-Lee (1989), a youth British engineer working at CERN in Switzerland, distributed a proposal for an in-house online document sharing system. He described it as a “Web of Notes with links” and a new system called, the WWW (World Wide Web). Lotus Notes release 1.0 was released and it includes functionality which was "revolutionary" for the time, including allowing system/server administrators to generate an user records, user mailbox, with Name and Address database and to notarize the user's ID file through dialog boxes.

During 1991, the Smart Board was introduced. Johnson-Eilola (1990-91) explained that, a “Smart Board system provides a 72-inch, rear projection, touch screen, intelligent whiteboard surface for work.” Eilola explained how the smart board works. The smart board permitted the different users to work with a large amounts of information.

During the year 1992, the earliest full motion video MPEG compression techniques were developed and full motion video available for all manner of digital programs.

As early as 1997, Graziadei described an online computer-delivered lecture, tutorial and assessment project using electronic mail.

Goldberg (1995) at University of British, Columbia began the usage of web-based systems in education and develops WebCT. During this time, Microsoft was actively evangelized internet based learning to higher educational institutions for learning content developers and traditional education companies. In the mid of 1995, Microsoft rapidly migrated to the internet. Microsoft developed MOLI (Microsoft’s

Online University). Despite initial confrontation to this new learning model, several companies and institutions used MOLI as an experimental platform before launching their own offerings.

Chasen and Pitinsky introduced Blackboard Inc. in Washington in 1997. Simultaneously, Deamweaver platform also launched by Macromedia Company and maintained until Adobe Systems acquire it in 2005. It has supportability with W3C standards with various server side scripting languages and frameworks including Active Server Pages (ASP) JavaScript, ASP VBScript, ASP.NET C#, ASP.NET VB, ColdFusion, Scriptlet and PHP. Adobe Dreamweaver is a web page design and development application software that give a visual WYSIWYG editor to permit content to be opened in locally installed web browsers. The Dreamweaver version five supports syntax of scripting languages.

During the last two decades, server side scripting languages like Action Script, Active Server Pages (ASP), Cascading Style Sheets (CSS), ColdFusion, EDML, Extensible Hyper Text Markup Language (XHTML), Extensible Markup Language (XML), Extensible Stylesheet Language Transformations (XSLT), HyperText Markup Language (HTML), Java, Javascript, PHP (Hypertext Preprocessor), Visual Basic (VB), Visual Basic Script Edition (VBScript),Wireless Markup Language (WML) etc., were used to create E-learning tutorials.

Blake (2000), launched in 2000, with dozens of classes at the University of Texas at Austin. It provides websites and all the features offered by Blackboard like course documents, calendaring, grades, quizzes and surveys, announcements etc. Later, the company renamed as ClassMap. During January 2000, the ILIAS has developed at University of Cologne has become an open source software under GPL. The team of ILIAS found by Compus Source promoted the development of open source LMS and other software for teaching at Universities. On April 2000, ePath (1999) launched the first online LMS. ePath Learning ASAP, was made reasonable price for production firms to create and manage online learning programs Coursework and full-featured course management system were developed at Stanford University's Academic Computing. CW supported multiple courses allowing multiple roles for users. CW's consisted of a set of tools for authoring and distributing course websites including a course homepage, announcements, syllabus, schedule, course materials, assignments, grade book and assync discussion etc.

During the same time, Microsoft released the Microsoft Encarta Class Server. Martin Dougiamas published Moodle via CVS. Murray Goldberg and others started a company called Silicon Chalk. Silicon Chalk software was used in laptop for creating learning environments. The different features of Silicon includes, presentation, audio beaming to student laptops, student note taking, student polling, student polling, student questions, control of student applications, recording of entire lecture experience for archiving , searching etc. Thinking Cap, the first XML LMS / LCMS was also launched. In December 2001, the open-source course management system, spotter was also released.

An E-learning software like Atutor, the first public open source software was released in December 2002, ATutor Release News· and Moodle version 1.0 is released in August 2002 as the first Ph.D program in Media Psychology at Fielding Graduate University. The Sakai Project was founded, by promising to develop an open source Collaboration and Learning Environment for the needs of higher education.

OLAT 4.0 (2005-06) was introduced with many new features like the integration of XMPP, RSS, SCORM and an extension framework that allows adding code by configuration and without the need to patch the original code set. EADTU (2005) – the European Association of Distance Teaching Universities launched the "E-xcellence” project, with the support of the eLearning Program of the European Commission (DG Education and Culture), to set a standard for quality in E-learning. On October 2006, OLAT 5.0 has been released which brings a comprehensive full text search service to the systems core. The addition of a calendar and wiki 32 component stresses the emphasis of a collaborative environment. AJAX and web 2.0 technologies are controllable by users.

During the year 2007, Microsoft released the Sharepoint Learning Kit. The software is SCORM 2004 certified and used in conjunction with Microsoft Office Share point Server to provide LMS functionality. On October 18, Controlearnings.a. and ocitels.a. designed and developed Campus VirtualOnline, (CVO), a platform mixed with E-learning content, e-books, e-money, e-docs, e-talents is found in a single place.

In the year 2010, Large LMS providers started to dive into the talent management systems market, possibly by starting a global tendency to do more with the information about LMS users. Later Epignosis released its Web2.0 virtual learning environment (eFront) as Open-Source software.

Papert and Harel (1991) suggested constructivism approach that, emphasis on knowledge is constructed upon experiences and the mental constructions or beliefs that, anybody uses in order to understand objects or facts. However, Vygotsky (1962) focused on the communicative and cultural dimension of learning, attempting a social-political approach. A progression of those two theories (Holmes and Gardner, 2006) introduced a third dimension in the interaction between learner and its environment. This dimension based on the other participants (learners and educators).

Paulson 2002, explained about the services of LMS. It includes access control, prerequisite of learning content, communication payment, and organization of user group. In New Zealand, the close Source Virtual learning environment Project evaluation and Moodle, as a part of an recognition and choice of appropriate open source E-learning environment to build up the use in educational institutions. Moodle was shortlisted from more than 30 options and recognized for its user friendliness, flexibility, excellent credentials, and growth to meet SCORM standards, along with ease of access to developers, modular architecture, and the existence of a lively developer community.

Mayer (2004) argued that, there are no models or learning theories exclusively designed for E-learning but only “electronic” enhancements of them. Furthermore, it is clear that although teachers and students are innovative regarding ICT in education, many efforts have not been widely accepted due to deficient design and implementation outcomes. This problem becomes more complicated as technology evolves and Virtual Worlds applied as educational tools. Virtual worlds offer an opportunity to the learners, to be engaged in activities that continuously measure their performance and assess their apprehension. According to Dewey (2008), real learning should be based on experiences; to gain new knowledge, continuous testing and assessment are necessary. From this point of view, traditional learning theories are omnipresent and should not be ignored no matter, how intensive the technological progress. This proposition is the major breakthrough in the LMS development environment.

Ham et al. (2007) commented on the needs of students in some institutions and developed partial PLE’s but he suggested the three key challenges for education institutions for transition to a student centric system. He argued that,

- The main ownership and control of tools and its features rests with the institutions rather than learner.

- The nature of social networking softwares are allows for the development of ample and comprehensive networks. When there is a locking system for the software within the boundaries of an LMS, it leads to an opportunity for networking is restricted to a particular community.
- Increases in statistics of learners have self-regulating access to Web 2.0 tools.

Hayward (2009, cited from Adams 2011) described five stages of LMS with some capabilities. 1. Course management – there is support of multiple class sessions across a whole course with general goals, some of the additional tools for evaluation, discussion and feedback 2. Curriculum management – it provides meta-tools (both objectives management and content tagging) to handle relationships between a set of courses. These tools could used to index a curriculum across a curriculum or recognize ordinary attributes across courses 3. Classroom management – facilitate release of notes or other learning support for a particular lecture (distribution of materials from the lecturer through websites), 4. Learning management –the information is organized around the learner and can facilitate independent learning as students can choose from a variety of knowledge based learning opportunities and can improve at different rates over time depending on personal goals. Students may have a classified area within the system to collect preferred resources (Facilitating the use of an e-portfolio) 5. Community management – it enables limits to expand beyond the class, course, curriculum, or the conventional campus learner, allows for multiple learning contexts and organizations.

Ellis (2009) portray a 'robust' Learning Management System as a system, which has the capability to a. Centralize and computerize administration b. Use self-service and self-guided services c. Assemble and deliver learning content rapidly d.

Consolidate training proposals on a scalable web-based platform. e. Support portability and standards f. Personalize content and enable knowledgere-use.

Pina (2010) described that, LMS have become nearly universal across the higher education as a core component of E-learning and referred to as blended learning. He also explained LMS as a broad phrase used for an extensive range of system that organize and offer access to online learning services for students, teachers, and administrators. Moodle software is freely obtainable for download and accomplishment since 2002, and is developed and supported by an active group of people like developers, clients (students), and administrators that keep the software evolving at a stable pace.

Mott (2010) argued that, an administrative organization and pedagogy of LMSs continues to hinder important teaching and learning innovations because:

- LMS's generally organized around discrete, capricious units of time (academic semesters) and courses usually expire and vanish at the end of semesters, thereby cut short the connection and flow of the learning process.
- LMS's are educator-centric. Teachers create courses, upload content, begin threaded pondering, and form a cluster. Opportunities for student- initiated learning actions in conservative LMS are severely inadequate.
- Courses developed and delivered via LMS are called 'walled gardens'. It is restricted to those formally enrolled in them. This constraint impairs helps to share the content across courses, conversations between students within or across degree programs and all self- motivated learning affordances of read-write web.

Eckstein (2010) summarized, the selection of LMS is a solemn choice for any University and likely to have a major effect over a number of years. There are two main categories of LMS's available in the market- proprietary (paid for) and open source. Most of the propriety systems are based on Microsoft .NET and/or Java technologies. Examples of proprietary LMS include Joomla LMS, Learn.com, Saba Learning, and Suite Blackboard.

The majority of the open source systems are based on PHP (scripting language), Apache server and MYSQL database, installation method is very simple and inexpensive (or free) and the software for each open source LMS is at no cost to download, install, use and update, and all have complete free documentation and forum. For an instance of open source LMS include Moodle, Claroline, Sakai Project and aTutor.

Walsh and Coleman (2010) opinioned that, Moodle 2.0 is the newest version and its new features centered on improved usability, including, easier navigation, enhanced user's summary, community hub publishing and downloading, a new boundary for message features permits teachers to verify student work for copying. Text formats also permit plug-ins for embedded photos and videos in text.

They also identified the similarities of Blackboard 9.1 and Moodle. They identified the improved feature that anyone can setup Moodle's 2.0 community hub, which has public and private directory of courses. Added to this, Moodle allows teaches to search all of the public community hubs and download the courses as a templates for developing their own courses. Teachers can see the student's activities or task and can see the reports of student's progress after completion of the course.

Pinna (2010) also opinioned that, there are more than ninety different types of LMSs offered by the company. The second generation of LMS's are characterized by modular architecture designs, recognitions of the need for semantic exchange, amalgamation of standards-compliant platforms and improved shift towards the ‘services’ principle, where as aspects of functionality are externally exposed. Yau, Lam et al. (2009) articulated his opinion that, second generation of LMS remains content or teacher centric, rather than learner-centric.

Pina (2010) also explained about Moodle. He said that, since 2002, Moodle is freely available for download, fully developed, and supported by an active community of developers; users and administrators to keep the software evolve at a steady pace. LMS designed from Moodle clearly conceptualized to support social constructivist framework of education social constructivist framework of education. Where, the students actively participate and involved in construction of their own knowledge.

The idea behind this philosophy of learning is – learners actively construct new knowledge and they can learn more by explanation what they have learnt to others, as well as by adopting a more subjective example to the knowledge being created (Barr, Gower et al. 2007).

Pina also commented that, Moodle interface have the features set similar to commercial LMS, where, the focus of the interface reflects the Moodle’s constructivist roots, and is focused on ease communications and social interaction. Identification of LMS market share information is very difficult to ascertain. However, there is a general agreement that Blackboard and Moodle are responsible for large section of LMS market. Hence, an extensive evaluation on Moodle was carried out during this study.

Virtual Learning: Educational Theories

The quality of online education depends on the proper use of digital technologies in accordance with modern educational theories. The theories have been elaborated in this context as follows:

Behaviorism. Behaviourism examines how students behave while learning. It focuses on how learners respond to certain stimuli. When the teacher repeats the stimuli, they can observe, control, and modify the learner's individual behaviour. Learners do what they are instructed to do and are only prepared to reproduce basic facts and automatically perform tasks. Behaviourism does not examine the mind or cognitive processes.

In virtual learning behaviourism can be applied through step-by-step video tutorials, game-based activities, regular and constructive feedback, quizzes, gamification, etc (Mayes and Freitas, 2004)

Cognitivism. Cognitivism focuses on the role of the mind and cognitive processes in learning. It explains how the brain is functioning and the levels of cognitive development that form the foundation of learning. Studies of cognitivism help educators understand how people learn and how to teach more effectively.

In virtual learning cognitivism can be applied through customizable learning environments, adaptive and personalized learning applications, AI, learning analytics, etc. It is important to provide content that is tailored to your learners' cognitive abilities, such as text, images, multimedia, etc., in which the learners can choose how lessons are presented. (Mayes and Freitas, 2004)

Social Constructivism. Teaching and learning are explained as complex interactive social phenomena that take place between teachers and students. Learning activities focus on experience sharing, teamwork, and collaborative learning.

Social constructivism finds perfect application in group discussions, brainstorming, problem-based learning, and small group activities. A great environment for these types of activities is the virtual classroom for live online teaching with interactive tools like collaborative web-conferencing, an online whiteboard, breakout rooms, screen sharing, etc. (Mayes and Freitas, 2004)

Characteristics and Benefits of VLE

The reason to implement any new technology is making something better, simpler, and faster. The VLE implementation in educational scenario makes no exception. Virtual learning creates opportunities for students to connect to the learning that is important for them. Some of the significant characteristics and benefits of VLE are discussed below (S.A. Barab, R. Kling, and J.H. Gray, 2004):

- **Virtual Learning is Not Bound by Venue or Time.** Virtual learning impacts the connection between school and home. The connection between home and school becomes quite seamless—whether it is home, as in the physical home that the student lives in, or outside-of-school places such as the local library, local café, a friend's house, grandma's house that they might visit after school. Students connect with the work that they are doing in online worlds which makes the use of a virtual learning environment very high impact.

- **Virtual Learning has Greater Global Reach.** Another factor about virtual learning is the global reach that's now possible for students. Once they had to rely on resources from the local library. Or, from time-to-time, a visitor to the school could provide them with a feel or an insight into what it might be like in other lands or countries that they might be studying. Now, global reach means that they can reach directly into the lives of those who live in some of those countries and lands. They can talk to experts who have visited there, and are familiar with the geography, the terrain, and some of the social issues that might occur there. And they can connect with learners in those areas to collaborate on projects, to look at topics that are germane to them. So, the global reach is becoming increasingly important as students become prepared to be citizens in a much more globalised society than they have previously.

• **Virtual Learning Benefits Teachers.** And lastly, when we are thinking about virtual learning we can't forget about the impact on the teachers themselves-the impact that virtual learning opportunities are having for teachers in their own professional learning and development. Many schools are starting to see that engaging in virtual professional learning and development is of benefit to both the school and teacher-not only in the cost-saving from days off, teacher-release days, and travel, but also the benefit of continuity. Where the investment may have been made simply to get to a one-day course, seminar, or workshop, now, teachers can have access to their professional development over many weeks or months, for a similar size investment. What's more, it connects them with other educators doing similar things that they are, and who are looking for ways to improve their own professional activity and professional futures in that way.

So, virtual learning has a very broad application. It's not only about online courses, but also about the way that we extend what is happening in the premise of school – way beyond the school gates.

• **Flexibility as a Benefit of Online Schools.** Among the many advantages of an online education, you'll find virtual classrooms are great for people who are advancing their education while working. In a traditional classroom, lectures will be scheduled at a specific time of day and your schedule will be formed around the availability of classes. If you're currently employed and courses aren't available after your working hours, it can be difficult to juggle a course load in addition to your work duties.

When attending a virtual campus, online learning allows for far more autonomy in deciding your own schedule. That means you can study whenever it's convenient for you. Live with some noisy roommates? Having more control over your schedule also means you can avoid distractions easier. Because your schedule isn't dictated by classes, you can spend more time doing the things you want. That might mean focusing on your career or spending time with your family. All you need is a digital device and an internet connection, and you have access to the necessary tools to further your education and earn your degree.

- **Cost Advantages of Online Learning.** Education can be expensive, but virtual learning can provide a number of ways for students to save. Not having to commute to campus can help you save on transportation costs. It also means saving time because you don't need to travel to-and-from campus. Every year, the average student spends more than a thousand dollars on textbooks and course materials. Virtual coursework often takes advantage of virtual resources, which translates into less money spent on textbooks.

Tuition costs can also vary between online and on-campus programs. For instance, at Drexel University, students enrolled in online programs in the School of Education receive a 25% discount off the price of regular tuition. Most online programs offered by the school are also financial aid eligible. Between all these sources of savings, cost cutting can be an enormous advantage of virtual learning. Plus, in the event of inclement weather, you don't have to worry about being able to make it to class, or about your classes being unexpectedly cancelled. However, if there is a power outage and you're unable to access the internet as a result of weather conditions, there may be difficulties with missing a scheduled online class, but it may be easier to make it up.

• **Advantages of Virtual Learning with Course Variety.** Among the many educational benefits of virtual learning, some are easier to identify. Online courses allow you to earn essentially the same range of different degrees that can be earned from a traditional educational environment. That includes learning certificates and professional certifications to master's degrees or doctoral degrees.

Integrating coursework with technology provides a number of advantages. Rather than waiting days or weeks after exams, you can often get immediate feedback. Where a traditional lecturing leaves you at the mercy of your best note-taking skills, video presentations can be watched and revisited as necessary. Students who find their focus suffers from classroom activity may benefit from online classes. Students who aren't as assertive may have better opportunities to participate in class discussions when communicating online. Working from your own choice of environment, with self-paced learning, the result can be a more personalized learning experience.

• **Career Advancement Opportunity Benefits of Virtual Learning.** Just like courses taken in a traditional classroom setting, virtual learning can provide you with a number of career advancement opportunities. But online students have better opportunities to collaborate with international classmates, and often have more individual contact with other students. Students may also receive more one-on-one time with their professor with virtual learning, which is beneficial for both learning and networking. Because you're the master of your own schedule, students of virtual learning are better prepared to continue working while pursuing academic credentials. And for students who aren't employed, academic work can serve to explain any discontinuity or gaps in a resume. In either case, the advantages of virtual learning can be clearly seen on a resume.

- **Flexibility.** With the help of VLE, the educational process becomes more flexible, especially in terms of time. Having permanent and free access to all the learning materials, students can easily align their studies with other plans and activities. So, it gets simpler to continue education even having a full-time job or an infant demanding much time and attention. In addition to that students are free to work at their own pace. Everyone can read the texts and watch the videos as many times as they need to understand the topic, while fast learners do not have to wait for the rest of the group to move further.

- **Accessibility.** Since learning can be done online, there is no need for attending classrooms. This makes high-quality education available for disabled people as well as for those living in remote areas or even on other continents. The virtual learning system also facilitates a non-stop educational process as one can continue studies even on vacation, business trip or lying in bed with a cold.

- **Affordability.** Another significant benefit provided by VLE implementation is that getting a degree even at top universities becomes cheaper because there is no need for paying campus fees. The situation is even better for foreigners since they do not have to spend large sums of money on moving to another country.

- **Simple Management.** Virtual learning environments help teachers to plan lessons, manage administrative work, track students' performance, activity, and level of engagement as well as provide additional materials and support for those who need that. With VLE it is also easier to analyze the efficiency of the current curriculum and to update it if needed.

• **Engagement.** The virtual learning environment is friendly to experiments with formats of content and new approaches. It empowers educational roadmap with online tests and quizzes, videos and podcasts. Mixing different activities allows better students' engagement and adding more gamification to the learning process.

- Access to digital learning materials: texts, videos, images, podcasts, etc.;
- Group discussions and one-on-one chats with a teacher;
- Submitting homework and other tasks;
- Grading, tracking students' performance, providing feedback;
- Holding live lessons.

There are many advantages to virtual learning that can help you sharpen your skills and grow in your career. Courses taught online provide students the flexibility to learn on their own schedule, instead of a mandatory class time. Virtual courses give students more selection in their courses. In a face-to-face setting, courses taught at the same time fore students to choose between courses they like. Lastly, virtual learning gives students access to classmates all around the world, providing networking opportunities you can't get through an on-campus program.

Challenges of Virtual Learning Environment

Along with significant benefits, there is a list of drawbacks to consider when implementing a VLE solution (Barab et al., 2004).

• **Motivation.** The flexibility of a virtual learning environment can turn out to be a problem for people with a lack of self-discipline or with weak motivation (like some pupils at school). Without permanent control and strict deadlines, it is hard for them to stay concentrated and study effectively. In addition to that, VLE opens more opportunities to cheat since no one sees if you are using another device while having an online test or actually doing everything yourself. So, self-discipline and high motivation get crucial.

- **Limitations.** Not all learning activities can be done online: you cannot conduct a sophisticated chemical experiment in your bedroom or train dentist skills without special equipment. This makes some courses and degrees either too theoretical for further usage or available only within the traditional learning system. One more limitation here is delayed answers. Studying in the classroom, you can ask any question and get an immediate teacher's answer while online education implies time flexibility for everyone, including teachers.

- **Communication.** Even though VLE systems provide a lot of tools to facilitate communication - chats, group discussions, live lessons - they cannot allow the same level of engagement as face-to-face conversations. This not only discourages warm relations and mutual assistance in a particular group but also prevents students from developing communicative and conflict-solving skills they will need in real life.

- **Investments.** The implementation of the virtual learning environment requires time and money investments from the educational institution. The VLE system has to be either chosen from the existing solutions or developed from scratch, the staff has to adapt to new ways of the learning process organization.From the students' perspective, there is also a place for significant investment. In the USA and Europe, we are used to having personal computers and permanent internet access but there are still a lot of countries where people cannot afford a laptop or have too poor telecommunication services.

Virtual Learning Systems in the Classroom

An electronic classroom is a classroom equipped with advanced information technologies, which are used by instructors and/or students to store, retrieve, process and communicate information in support of learning activities. Electronic classrooms have been used in various disciplines including science, engineering, business, and management and languages. Application of IT in the e-classroom takes two primary forms: a means of information presentation and display, and interactive use of information technology by students and instructors as a basis for active learning and communication during class. The information presentation and display features of the electronic classroom aims at enhancing efficiency of learning and technology process e.g. include computer display of lecture notes, electronic note-taking by students and access to and display of online database.

The interactive use of VLS aims at support of student's active and exploratory learning during class. This approach to the use of technology in the electronic classroom is based on the cognitive learning theories that view learning as an active constructive process. Interactive use of VLS in the classroom in the form of network computers in conjunction with specialized software tools referred to as groupware can greatly enhance communication and discussion for e.g. use of these allows students and faculty to brainstorm and share ideas , comments and criticize their ideas , and collaborate in solving problems and performing various tasks (Alves & Miranda, 2017).

The list of significant advantages of virtual learning environment is followed by a range of disadvantages. But there is a perfect way to avoid difficulties — mixing online and traditional education. Blended together, they provide students and teachers only with their best features making the learning process as effective as it can be

- Student-to-teacher and student-to-student communication remains live, hence, more effective and involving;
- The learning process is empowered with interactive online activities and additional materials to deepen knowledge;
- Students can get more individual curriculum according to their learning pace and interests;
- Tasks can be submitted and commented online;
- It is easier to catch up in case of illness, travel or any other reason to miss classes;
- Teachers get computer-aided assistance in planning lessons and managing all the related activities;
- Speaking of schools, parents can be more aware of their child's performance and more engaged in the educational process.

In case a virtual learning environment is used by an enterprise to teach employees, it is also possible to reap only the benefits of this system by combining online education and live communication with mentors and colleagues. As online learning continues to mature and as more K-12 schools use online courses as part of their curriculum, online learning myths will fade further into the background and e-learning will be seen as a valued option for all learners.

Conclusion

A theoretical analysis on virtual learning environment reveals how virtual learning environment offers immersive learning experience, where learners experience the real environment in virtual manner. Virtual learning environments have become a part and parcel of an education institution's wider learning management system (LMS). The historical development of VLE as we experience it today is traced out. The theoretical overview emphasises the need and benefits of virtual learning environment and also mentions the challenges posed by VLE. Suggestions to overcome the limitations are sorted. Virtual learning thus brings new pedagogical techniques into the traditional forms of education and makes learning more personalized and convenient.

Geogebra

GeoGebra can be simply defined as an interactive geometry, algebra, statistics and calculus application, intended for learning and teaching mathematics and science for all levels from primary school to university level. GeoGebra is available on multiple platforms with its desktop applications for Windows, macOS and Linux, with its tablet apps for Android, iPad and Windows, and with its web application based on HTML5 technology (Hohenwarter & Preiner, 2007)

GeoGebra was created to help students gain a better understanding of mathematics. You can use it for active and problem-oriented teaching, it fosters discoveries and mathematical experiments in classroom and at home (Hohenwarter et al., 2007).

Its creator, Markus Hohenwarter, started the project in 2001 (as part of his master's thesis) at the University of Salzburg, continuing it at Florida Atlantic University (2006–2008), Florida State University (2008–2009), and now at the University of Linz together with the help of open-source developers and translators all over the world. After a successful Kickstarter campaign, GeoGebra expanded their offerings to include an iPad, an Android and a Windows Store app version. In 2013, Bernard Parisse'sGiac was integrated into GeoGebra's CAS view.

GeoGebra includes both commercial and not-for-profit entities that work together from the head office in Linz, Austria, to expand the software and cloud services available to its user community.

Geogebra is an open source application designed specifically for the learning and teaching of geometry, algebra, and calculus classes. The application includes a dynamic calculus tool that can modify the representation of the graph in real time, as you change the values. This is a very useful tool for the academic setting, whether it be for students or for the demonstrations teachers use in front of the class.

GeoGebra provides a dynamic platform for all levels of education that integrates geometry, algebra, spreadsheets, graphing, statistics and calculus in one easy-to-use package (Hohenwarter & Preiner, 2007). GeoGebra is a rapidly expanding community of millions of users located in just about every country. GeoGebra has become the leading provider of dynamic mathematics software, supporting science, technology, engineering and mathematics (STEM) education and innovations in teaching and learning worldwide. Some features of Geogebra are

- Free to use software for learning, teaching and evaluation
- Fully interactive, easy-to-use interface with many powerful features
- Access to an ever-expanding pool of resources at tube.geogebra.org
- Available in many languages
- A fun way to really see and experience mathematics and science
- Adaptable to any curriculum or project
- Used by millions of people around the world

Interactive Geometry, Algebra, Statistics and Calculus

Geogebra provides ample opportunities such that constructions can be made with points, vectors, segments, lines, polygons, conic sections, inequalities, implicit polynomials and functions. All of them can be changed dynamically afterwards. Elements can be entered and modified directly via mouse and touch, or through the Input Bar. GeoGebra has the ability to help students provide experience of using variables for numbers, vectors and points, help in solving mathematical functions such as to find derivatives and integrals of functions and has a full complement of commands like roots, log values and extremum. Teachers and students can use GeoGebra to make conjectures and to understand how to prove geometric theorems (Hohenwarter & Preiner, 2007).

Its main features are:

- Interactive geometry environment (2D and 3D)
- Built-in spreadsheet
- Built-in Computer algebra system (CAS)
- Built-in statistics and calculus tools
- Allows scripting
- Large number of interactive learning and teaching resources at GeoGebra Materials

GeoGebra Materials Platform

Dynamic GeoGebra applets can be directly uploaded to the GeoGebra materials platform, the official cloud service and repository of GeoGebra related and interactive learning and teaching resources. GeoGebra materials was initially launched under the name GeoGebraTube in June 2011 and renamed in 2016. With recent improvement and extended functionality the service now hosts more than 1 million resources (April 2016), 400,000+ of which are shared publicly as searchable materials - such as interactive worksheets, simulations, games, and e-books created using the GeoGebraBook feature.

GeoGebra materials can be also exported in several formats, including as static images or as Animated GIF. SVG vector images can be further edited using third party software, e.g. Inkscape. EMF vector formats can be directly imported in several Office applications. There are also options for exporting to the system clipboard, PNG, PDF, EPS. GeoGebra can also create code that can be used inside LaTeX files through its PSTricks, PGF/TikZ and Asymptote export options.

Licensing. GeoGebra's source code is licensed under the GNU General Public License (GPL) and all other non-software components are under Creative Commons BY-NC-SA.[5][6] Thus, commercial use is subject to a special license and collaboration agreement.

Community. The International GeoGebra Institute (IGI) is the not-for-profit entity of The GeoGebra Group, coordinating deployment and research efforts across a global network of user groups at universities and non-profit organizations. IGI joins teachers, students, software developers and researchers to support, develop, translate and organise the GeoGebra related tasks and projects. The local user groups support students and teachers in their region. As part of the International GeoGebra Institute network they share free educational materials via the GeoGebra Materials platform, organize workshops, and work on projects related to GeoGebra. The International GeoGebra Institute may certify local GeoGebra users, experts, and trainers according to certain guidelines.

GeoGebra Classic includes the following math tools:

- Graphing: plot functions with sliders and solve equations
- Geometry: create interactive geometric constructions
- 3D Graphing: graph functions, surfaces and many more 3D objects
- Spreadsheet: analyze data and do statistics connected with graphing
- CAS: solve math problems with our powerful computer algebra system
- Probability: visualize parameters and distributions quickly
- Search for free learning activities directly from the app
- Save and share results with others

Applications of GeoGebra

GeoGebra is a dynamic and interactive mathematics software for geometry, algebra, calculus, trigonometry and statistics. Tools in GeoGebra are helpful in various constructions and calculations. Entry of equations and mapping of various variables can be done using the tools, input bar, CAS and spreadsheet views. Interactive explorations can be done using the tools in 2D and 3D Graphics modes.

GeoGebra is a very useful tool to learn and teach different branches of mathematics. GeoGebra desktop application are available for Windows, Mac OS and Linux and tablet applications are available for Android, iPad and Windows. Its web app is based on HTML5 technology. GeoGebra was created by Markus Hohenwarter and started as part of his master's thesis at the University of Salzburg, continuing at Florida Atlantic University, Florida State University, and then at the University of Linz with the help of open-source developers and translators all over the world. Bernard Parisses' Giac was integrated into GeoGebra's CAS view in 2013. Both commercial and not-for-profit entities work together to expand the software and cloud services for users.

Teachers can use GeoGebra to help make math more meaningful and visual for students. Teachers can quickly build digital worksheets that include simulations already created on GeoGebra. The tools also allow students to manipulate math concepts in one format and see them in another (such as how a 3D shape sits on a 2D plane, or how the algebraic function of a plane and a sphere changes as we change points on either -- or both). It helps students to make connections between different areas of math and how they relate to one another.

GeoGebra provides several powerful math tools including a graphing calculator, geometry tool, spreadsheet, probability calculator, algebra calculator and 3D graphing. With the Learnosity and GeoGebra partnership, Learnosity clients have access to thousands of ready-made STEM education materials to create interactive, engaging learning and assessment opportunities for students. GeoGebra brings math to life through intuitive, interactive visuals that connect graphing, 2D and 3D geometry, spreadsheets, and algebra as never before. GeoGebra offers real-world learning experiences through its world-leading dynamic mathematics software, which supports science, technology, engineering and mathematics (STEM) education and innovations in teaching and learning worldwide. With millions of active users, GeoGebra's growing community of learners and teachers can be found in every corner of the world. To support this expanding community, GeoGebra is available in multiple languages.

GeoGebra Resources

The main feature of GeoGebra is interactivity. Since static documents cannot capture the spirit of GeoGebra, and since most teachers/students don't have a web site of their own; it is possible to post ones working to the GeoGebra web site. The material shared is a so called GeoGebra worksheet.In order to share worksheets to the GeoGebra web site, either register to make a GeoGebra user account, or use an existing Google, Facebook, Microsoft or Twitter account.

Areas of use for Teachers. GeoGebra is useful for many situations when teaching mathematics. Some common areas of use are described below.

Teacher Demonstrations. When introducing new mathematical concepts, relations, or theorems, in some cases it is more efficient to use a GeoGebra worksheet than to visualize by drawing on the white board. Worksheets on the GeoGebra web site are shown as interactive tasks including instructions.

Student Activities. Students can use GeoGebra for mathematical problem solving, to make mathematical models, or to make mathematical investigations when introducing new concepts. A student activity can be organized as a longer experimental activity or as a shorter task during any traditional lesson. Student activities can be based on worksheets that a teacher has done beforehand or it can involve students using GeoGebra themselves.

Creating Images. A mathematics teacher must be able to create images to be used on tests, exams, written assignments, presentations, or web-based resources. GeoGebra is an excellent tool for creating images in this context.

An overview of GeoGebra. There are two views shown by default while starting GeoGebra, the algebra view and the graphics view. In the upper right corner of each view there are icons to show the view in a new window or to close the view.

The program has a user-friendly design which lets the user try it out by clicking on icons to create objects. Every object can also be created by writing a command in the input box.

The Tool Bar. Each icon in the toolbar will show a drop-down list of tools by clicking on the small arrow in the lower right corner of the icon. Each tool will let one enter an object in the graphics view, the toolbar help describes what is needed to make the object. If the toolbar help gives the hint to "select a point", it can be done by either selecting an existing point by clicking on it, or clicking anywhere in the graphics view to make a new point.

Properties. All objects have properties that can be changed. The most common properties can be changed by using the styling bar. If no object is selected, the styling bar will show common properties for the graphics view. When an object is selected, the styling bar for that object will be shown. In order to change the styles of the points defining a circle, first a point must be selected.

Names and Labels. Each object in GeoGebra is given a name (you can name it yourself or change the given name). The names of all objects are shown in the algebra view.If the algebra is shown when creating an object, the label will be shown by default. After an object has been created one can choose to show or hide the label by right-click on the object or use the styling bar.

Handle Many Objects. All points can be hidden by clicking on the Heading point in the algebra view. Then right-click on the selection and uncheck Show object. Many objects can also be selected by holding down Shift while selecting objects in the algebra view.

Geogebra- Ever Updating

From the first version in 2002, GeoGebra has improved a lot in its features and usability. International GeoGebra Institute (IGI) was started in 2008 for giving assistance for members of the GeoGebra community and for teachers who need support for using GeoGebra in their classrooms. This is a not-for-profit organization.

During the past years many GeoGebra institutes were started in different countries, where teachers, programmers, researchers and volunteers from all over the world work together on GeoGebra related projects and events. A repository of GeoGebra materials called GeoGebra Tube has been started in 2011 from which GeoGebra materials and worksheets can be downloaded by any interested person. GeoGebra materials prepared by users can also upload to GeoGebra Tube so that everyone who is in need can access that material. More than 714901 materials are available on GeoGebra Tube. Another mile stone in the development process of GeoGebra was the inclusion of three dimensional features in GeoGebra version 5. Using this feature students can visualize the three dimensional figures of mathematics and can understand the characteristics of three dimensional space clearly. In 2012, the team of GeoGebra developed the GeoGebra web application in collaboration with Google. It can run on every html5 capable browser. So without downloading and installing GeoGebra, a user can use it in any computer with internet. In 2013 GeoGebra tablet apps for Windows 8, Android, and iPad were released. This GeoGebra app is free to download. Anyone can download it from Google Play Store or Apple App Store. A team of experts are still working on it to make it the best mathematical software which helps students understand mathematics easily. The developers are updating the software according to the developments in the world of technology.

GeoGebra's User Interface

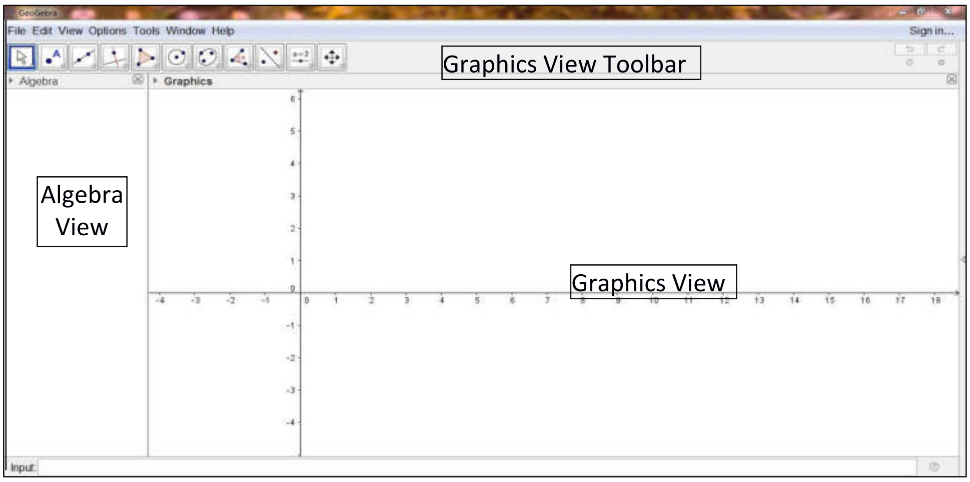
Mathematical objects can be viewed in six different ways in GeoGebra. They are; Algebra View, Graphics View, Spreadsheet View, CAS View, 3D Graphics View, Probability Calculator View. Each view has its own Toolbar from which different tools can be selected to create dynamic constructions. A wide range of commands and predefined functions and operators areal so offered in GeoGebra to make mathematical constructions.

Algebra View. Algebra View and Graphics View appear next to each other in GeoGebra by default. Algebraic expressions of mathematical objects can be entered directly using the Input Bar which is situated at the bottom of the GeoGebra window. As algebraic expression appears in the Algebra View, GeoGebra automatically displays its graphical representation in the Graphics View. A wide range of commands are also available in GeoGebra which can be used to create mathematical objects easily in the Algebra View.

Graphics View. Graphical representations of the mathematical objects are displayed in the Graphics View in GeoGebra. This View is part of almost all perspectives in GeoGebra. Graphics View toolbar contains many icons and every icon in the toolbar represents a toolbox that contains a selection of related construction tools. Using these tools different geometrical constructions can be made in the Graphics View. Graphical representations of mathematical objects can also be created with the help of Input bar. Algebraic expressions can be directly given to the input bar in order to construct their graphical representations in the Graphics View.

Figure 1

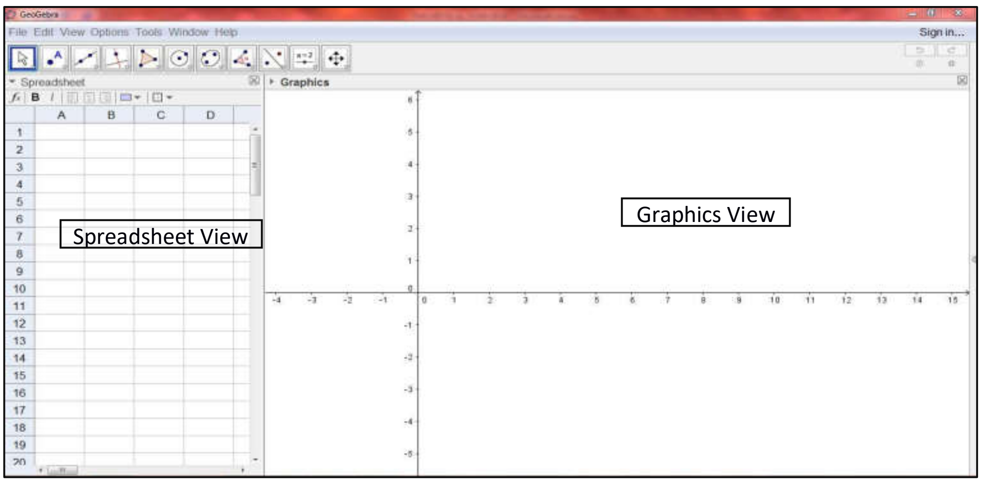
GeoGebra's Algebra View and Graphics View



Spreadsheet View. Spreadsheet view is appeared in GeoGebra next to the graphics view. A user can customize the spreadsheet view according to his or her preferences. Mathematical objects can be created in GeoGebra by directly entering numbers to the cells in the Spreadsheet View. Besides numbers, general objects such as complex numbers, Boolean values, matrices etc. and geometrical objects such as points, vectors, lines, functions etc. can be entered into the spresdsheet cells to create mathematical objects. It is also possible to import data from other spreadsheet software into the Spreadsheet View.

Figure 2

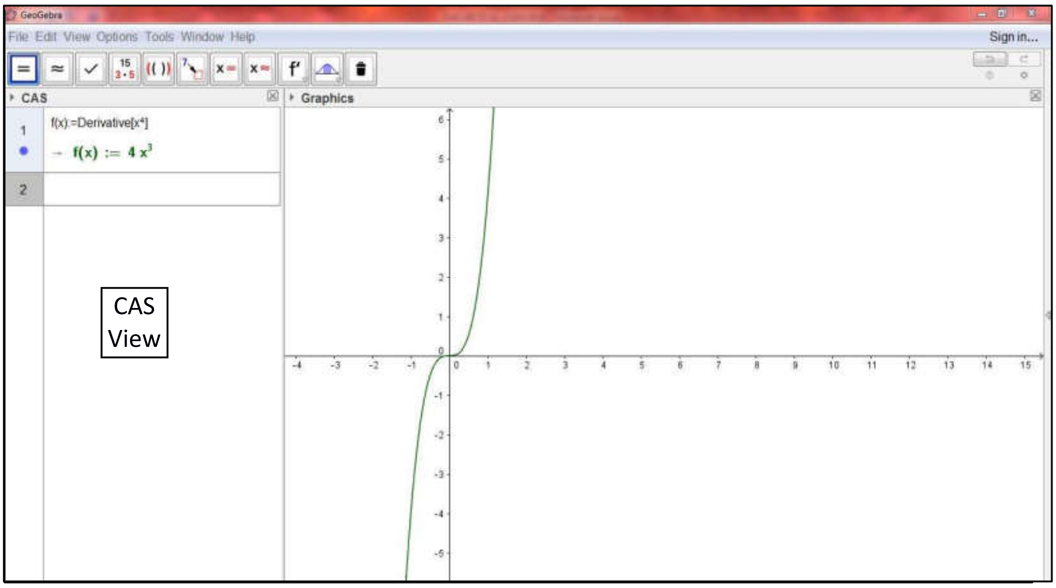
GeoGebra's Spreadsheet View



CAS View. CAS View is also opened next to the Graphics View by default. The CAS View allows using GeoGebra's Computer Algebra System (CAS) for symbolic computations. It consists of cells with an Input Field at the top and output display at the bottom. Graphical representation of an object in the CAS View can be viewed in the Graphics View. If a user wants to work only using the Computer Algebra System, then he can change the visibility status of the object in the Graphics View to Hide Object.

Figure 3

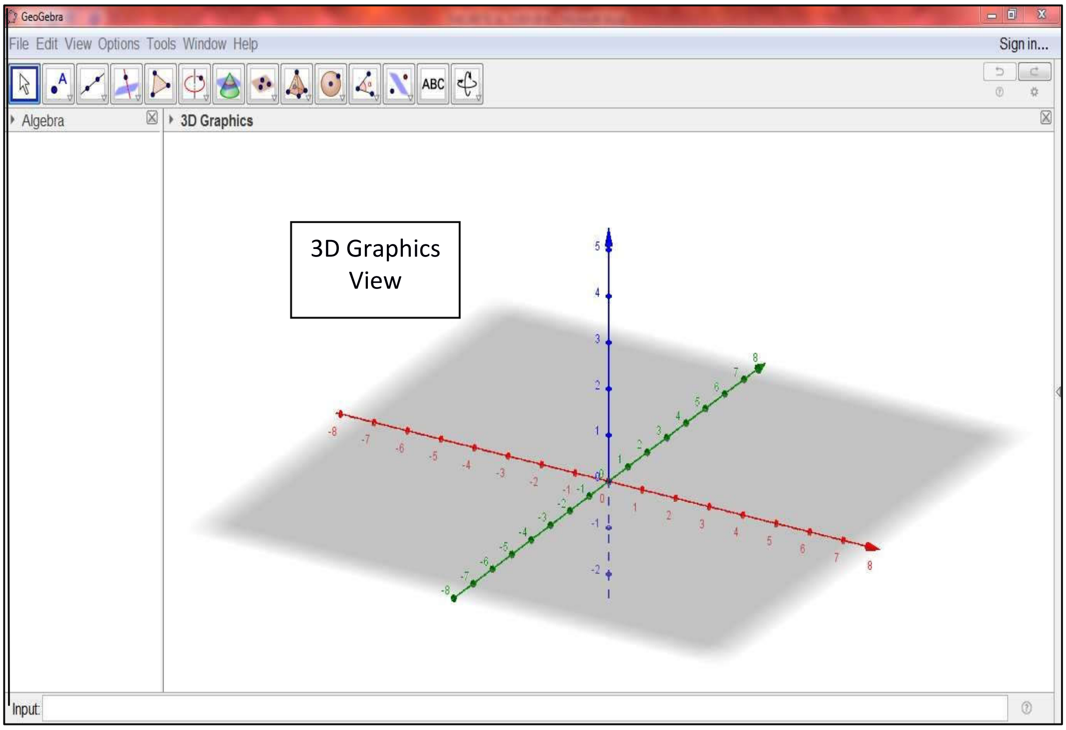
GeoGebra's CAS View



3D Graphics View. By default, the 3D Graphics View is opened next to the Algebra View. The Input Bar is displayed at the bottom of the GeoGebra worksheet. It is possible to customize the 3D Graphics View according to the mathematical topic. The basic setup such as display of coordinate axes, xOy-plane, grid etc. can be changed using the 3D Graphics View Style Bar. Three-dimensional graphical representations of objects can be created in the 3D Graphics view using the tools available in the 3D Graphics View Toolbar or entering the algebraic representation of mathematical objects in the Input Bar.

Figure 4

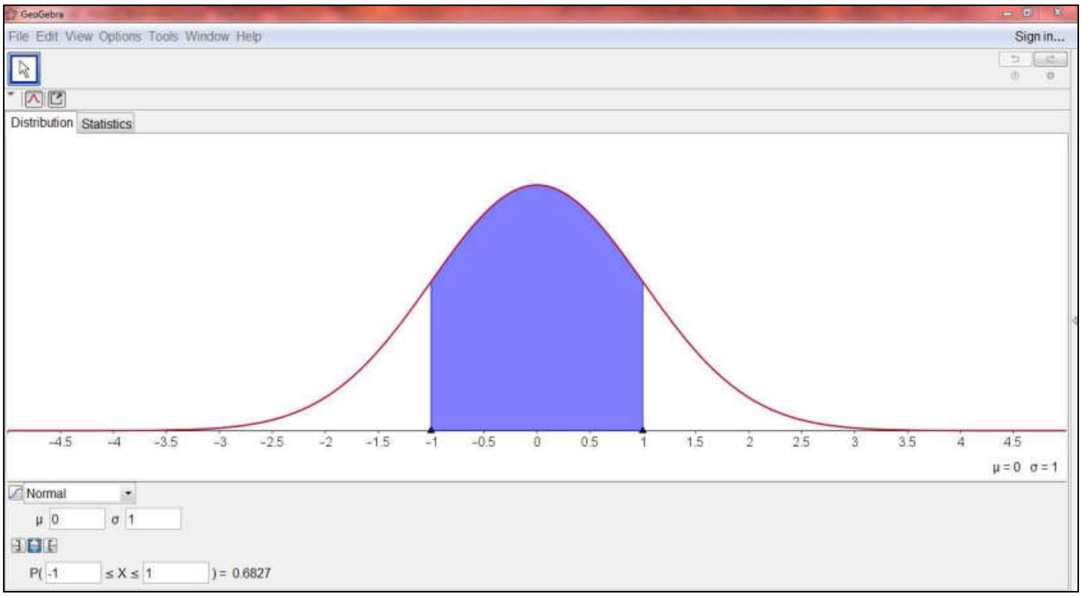
GeoGebra's 3D Graphics View



Probability Calculator View. Probability Calculator is used to calculate and graph probability distributions, as well as to conduct statistical tests. A variety of probability distributions can be drawn in the distribution tab using the list available in the drop down menu such as normal, binomial, chi-squared etc. It is possible to toggle between the probability density function and the cumulative distribution function of the distribution using the buttons provided in the Probability Calculator View. A Statistics tab is available in this view which allows conducting a variety of statistical tests. A user can select an appropriate test from the list available in the drop down menu. There is provision for specifying the null hypothesis and alternative hypothesis. The parameters of the test can be adjusted in the provided text boxes and GeoGebra will automatically provide the results of the statistical test.

Figure 5

GeoGebra's Probability Calculator View



Other components of GeoGebra's user interface are

- Menu Bar
- Input Bar
- Style Bar
- Navigation Bar
- Context Menu
- Virtual Keyboard.

The menu bar is at the top part of the GeoGebra window. The menus available in the menu bar are File Menu, Edit Menu, View Menu, Perspectives Menu (Web and Tablet App Version only), Options Menu, Tools Menu, Window Menu (Desktop Version only) and Help Menu. These menus allow users to insert images into a GeoGebra file, save, print and export constructions. With the help of these menus default settings of the program can be changed, custom tools can be created and the toolbar can be customized.

The input bar is located at the bottom of the GeoGebra window. Algebraic equations and expressions can be directly written in the input bar to create the corresponding geometrical constructions in the graphic view. Algebraic representations can also modify through the input bar. The geometrical representation will also change according to the modification. The pre-defined commands, functions and operators can also be used to create constructions.

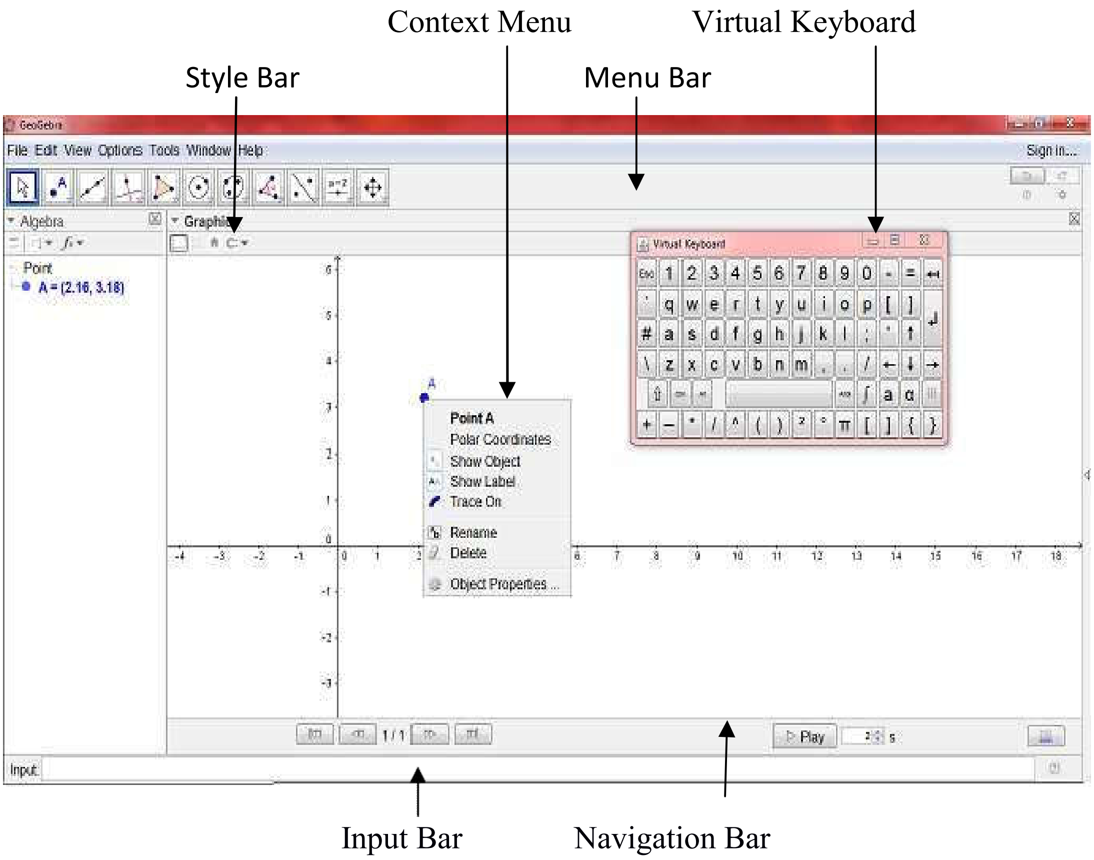
Basic properties of Views or objects can be changed quickly and easily with the help of Style bar. A user can show or hide the axes, show or hide the grid, select different types of grids for the construction, rotate the 3D graphics view, set the font style to bold or italic and change many more properties of the mathematical objects using the Style bar of different Views.

Navigation Bar allows navigating through the construction steps of the GeoGebra file. Users can redo a construction step-by-step by using the navigation buttons. There is an option for automatically play the construction step-by-step. Speed of this automatic play feature can be adjusted using the text box in the Navigation bar. The Context Menu provides a quick way to change the behavior or advanced properties of an object. The Context menu of a mathematical object can be opened by right clicking on it. Context menu allows a user to rename the object or delete it. The algebraic notation of the object can be changed using this menu. Other options in the context menu are Trace on and Animation on.

The Virtual Keyboard of GeoGebra is a semi-transparent keyboard containing the standard keyboard characters and the most used mathematical symbols and operators. It can be used with a mouse or other pointing devices.

Figure 6

GeoGebra's User Interface

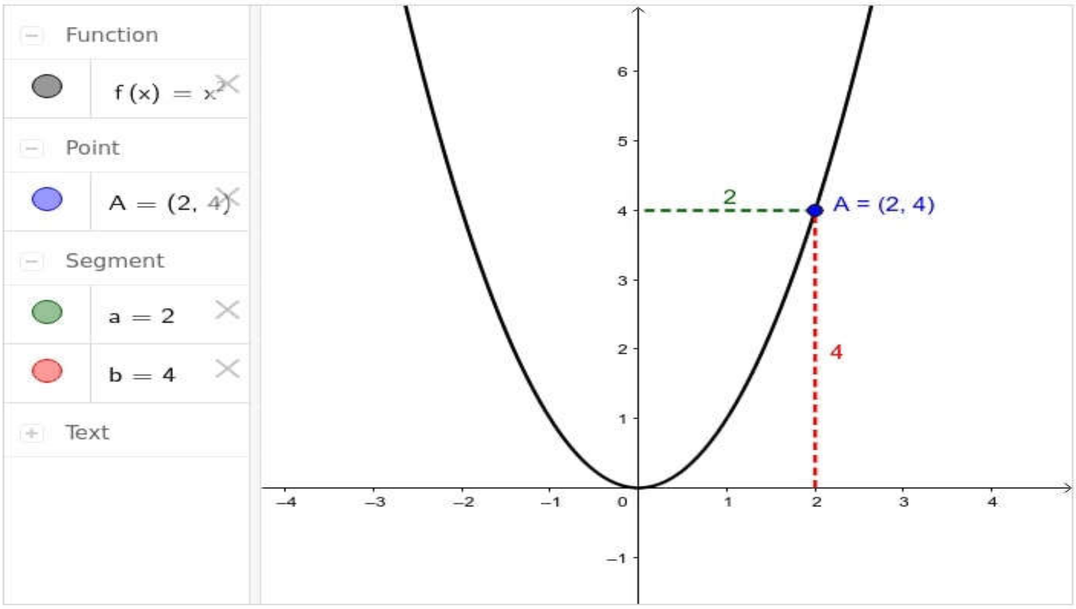


GeoGebra provides six standard perspectives corresponding to the six views. The different perspectives are Algebra, Geometry, Spreadsheet, CAS, 3D Graphics, and Probability. Using the Perspectives Sidebar a user can easily switch between different Perspectives. The Algebra Perspective consists of the Algebra View and the Graphics View. The Geometry Perspective displays the Graphics View without the coordinate axes. The Spreadsheet Perspective consists of the Spreadsheet View and the Graphics View. The CAS Perspective consists of the CAS View and the Graphics View. The 3D Graphics Perspective consists of the 3D Graphics View and the Algebra View. The Probability Perspective shows the Probability Calculator, which allows a user to easily calculate and graph probability distributions. A user can customize the user interface of GeoGebra according to his interest of topic.

Additional views can be added to the standard perspectives of GeoGebra. Other user interface components can also be added to the standard perspectives.

Figure 7

GeoGebra's Algebra Perspective



Preparation of Instructional Materials using Geogebra

Hohenwarter, the creator of GeoGebra designed the software for helping students to understand Mathematics easily. With the help of GeoGebra students can themselves explore and discover mathematical concepts. Even though GeoGebra was meant for students at the time of its creation, a large community including teachers, researchers, educationists and students use GeoGebra for their own purposes in these days. Teachers in different countries use GeoGebra in their classrooms to help their students easily comprehend mathematical concepts. Useful instructional materials can be prepared by teachers using GeoGebra. For this purpose, the software offers different export possibilities for dynamic figures, which were designed to be as easy to use as possible, in order to allow a wide range of teachers to realize their own visions of successful instructional materials (Preiner, 2008).

Basic Skills Needed for Preparing Instructional Materials Using GeoGebra

Some basic computer skills are necessary for preparing instructional materials with GeoGebra. Basic knowledge about GeoGebra is also essential for this purpose. But a teacher who has the basic computer skills can easily understand the user interfaces of GeoGebra and can create own instructional materials using GeoGebra.

Before trying to prepare an instructional material with the software GeoGebra, teachers should know how to create a new folder, how to name it and how to save files in different programs. They need to identify files from the extension of file names and they must be able to handle different types of files using appropriate software. They need to be able to navigate within the folder structure of their computers.

Teachers need to have the ability to handle picture files. There are many picture managing software are available which help to manage the pictures according to one's need. Knowledge in such software will help the teachers to enhance their instructional materials. They need to know how to find an appropriate image for their instructional material and how to download it. They should be aware of the copyright issues. Knowledge about the resolution of images will be an added benefit for teachers who are trying to prepare their own instructional material usingGeoGebra.

Awareness about text processing software is necessary for creating appealing instructional material. Application of basic formatting to the text, creation of tables, insertion of image into a text document and usage of an equation editor are some skills which will help the teachers to make attractive and useful instructional materials. Teachers should know how to take print out of afile.

Teachers must have knowledge about the usage of CDs and USB drives. They should know how to transfer files from computer to external storage devices and vice versa, how to handle a webpage and how to create hyperlinks. They must have awareness about the procedure of uploading files to an internet server so that their students can access those files online.

Static and Dynamic Instructional Materials. Based on the availability of resources and based on the topic of instruction, a teacher may need static instructional materials as well as dynamic instructional materials. GeoGebra supports the creation of both static and dynamic instructional materials. Print out of GeoGebra constructions can be used as a static instructional material. GeoGebra provides the provision of taking print out of the constructions directly from the GeoGebra worksheets. In the file menu there is the provision of viewing the print preview of the construction and in that window there are provisions for setting the scale of the graphic and giving a title to the construction. The construction steps can also be printed from the menu of the construction protocol window.

Static instructional materials which are part of text documents can be made using GeoGebra. The entire drawing pad or the selected area of the drawing pad can be exported to the computer's clipboard and it can be inserted into a word document as an image. Teachers can prepare handouts with sketches and constructions using this provision of GeoGebra. There is another option for exporting the graphics view as a picture. By using this option, it is possible to set the printing size of the picture and the picture will be saved in the computer for future use.

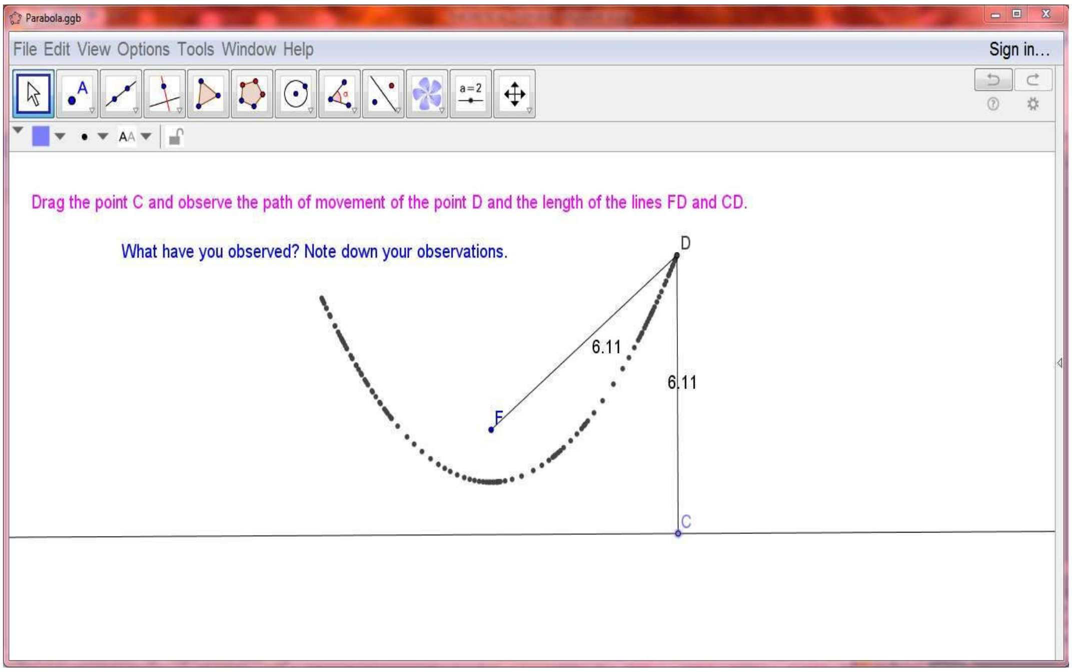
One of the most powerful features of GeoGebra is its ability to create dynamic constructions. Users are able to create dynamic worksheets demonstrating certain properties and features generally applicable to specific basic geometric objects and dynamically change the form of these objects (Velichova, 2011). These dynamic worksheets can contribute to a better understanding of mathematical concepts by allowing for interactive manipulations of the provided dynamic figure, and can foster active learning, as well as mathematical experiments. Additionally, dynamic worksheets can support guided discovery learning and encourage self-dependent learning as well as mathematical inquiries (Joolingen, 1999).

These interactive materials require some kind of browser software installed on the computer, as well as Java 1.4.2 or later which can be downloaded from the internet for free as necessary. Students don't need to know anything about the use of GeoGebra in order to work with these materials and don't need GeoGebra installed on their computers. Since dynamic worksheets can also be provided online, students can use them both in school and at home (Preiner, 2008).

An example for a dynamic worksheet is given in Figure 8. This worksheet allows students to explore the definition of a parabola. Instructions for students are given on the worksheet.

Figure 8

Example for a Dynamic Worksheet



Point F is the focus of the parabola and the point C lies on the directrix of the parabola. When the students drag the point C on the worksheet, the point D also moves. Students can check the length of the lines FD and CD as the point D moves. After working with this dynamic worksheet students can identify that when all the points which are equidistant from the point F and the line (on which the point C lies) are joined, they get the shape of parabola. Using this knowledge they can construct thedefinitionofparabolaasthesetofallpointswhichareequidistantfromafixedpoint and a fixed line in a plane.

After constructing interactive instructional materials in GeoGebra, teachers can export these as web pages using the menu File-Export-Dynamic Worksheet as Webpage (html). Before uploading to the internet, a window will appear in which there is options for giving title to the construction, write text above the construction and write text below the construction. Instructions for students can be given below the construction. Then clicking on the upload button will upload the GeoGebra file to GeoGebra tube.

Constructivism and Geogebra

GeoGebra can be used as a presentation tool in mathematics classrooms. When teachers get confidence in using GeoGebra in everyday teaching they can use this software as a tool which help their students to construct their own knowledge. Constructivism is a theory about knowledge and learning. This theory says that students construct their own knowledge and understanding about new ideas based on their previous knowledge. They construct new knowledge through experiencing things and reflecting on those experiences.

In a constructivist classroom students experience learning and then they continuously reflect on their experiences and thus develop increasingly strong abilities to integrate new information. In such a classroom, the main role of a teacher is to encourage this learning and reflection process. GeoGebra can be used effectively to construct knowledge. Students can experiment with Mathematics using GeoGebra. Discussions can be conducted in the class based on the results of their experiments. When students explore Mathematics using GeoGebra and through discussions teachers should give necessary support. These experiments and discussions will help students to construct their own knowledge. This constructivist approach redefines the role of teacher in the classroom from a person who reproduces a series of facts to a person who help students to construct knowledge.

e-Learning Principles in Geogebra

Clark and Mayer (2008) suggested some e-learning principles which should be satisfied by every e-learning tool and technique to be effective. The design of GeoGebra's user interface mirrors the intention of fostering effective learning by considering these e-learning principles. One of the principles suggested by them is Multimedia Principle. It is described as "Use words and graphics rather than words alone." GeoGebra combines text with graphical representations in several ways. A user can view algebraic representation and graphical representation of a mathematical object together in GeoGebra. The algebraic representation corresponds to the textual component, whereas the graphical representation adds the visual component mentioned in this principle. GeoGebra also allows to insert static and dynamic text into the graphics window to emphasize certain mathematical concepts and relations. The Multimedia Principle also influences the export possibilities of GeoGebra. A construction protocol can be exported for every construction or dynamic figure giving a textual description of all objects within a table as well as a picture of the actual construction (Hohenwarter, et al., 2008).

Another e-learning principle which is invested in multiple ways within the design of GeoGebra's user interface is Contiguity Principle. This principle is described as "Place corresponding words and graphics near each other." GeoGebra places corresponding words (mathematical expressions) and graphics near each other, making it easier to find corresponding representations of the same object (Hohenwarter et al., 2008). GeoGebra provides pop up text that show the definition of an object when the mouse is moved over one of its representations. Labels can be given to objects in the graphics view and this label can be the name or the algebraic value of the object. It is possible to give both the name and value of the object as label. The label follows the movements of its object. Therefore, the graphical and algebraic representations of the object always stay close to each other.

Coherence Principle is described as "Adding Interesting material can hurt learning". This e-learning principle is also taken into account by avoiding unnecessary distractions like glaring colors or decorations within GeoGebra's user interface (Hohenwarter et al., 2008). Also, unneeded objects can be hidden in both windows to avoid distracting the students and help them to focus on the relevant components of a dynamic figure.

Advantages of Geogebra

- GeoGebra is open-source software. It is free for non-commercial use. Teachers and students can download GeoGebra from the Internet and can be used in school as well as at home without any limitations (Hohenwarter & Lavicza, 2007).
- GeoGebra can be used in any computer with internet connection using the WebStart version. Updates are made automatically for the GeoGebra WebStart. So a user will always have access to the newest version of GeoGebra.
- GeoGebra integrates the easiness in manipulating dynamic geometry software with selected features of a computer algebra system.

- GeoGebra provides multiple representations of mathematical objects. A user can view both algebraic and graphical representation of a mathematical object together in GeoGebra.
- In GeoGebra the need for a bidirectional combination of dynamic geometry and computer algebra has been realized. The different representations of mathematical objects are dynamically connected enabling GeoGebra to adapt each representation to modifications of its counterpart.
- GeoGebra can be used without any advanced computer skills. It has simple user interface and can be used by students of different grade levels.
- Users can upload GeoGebra dynamic worksheets to GeoGebra Tube without restrictions. So teachers can share their instructional materials for their students and students can use it whenever they are in need of it.
- Since GeoGebra is programmed in Java, it runs on virtually any operating system by just requiring a Java plug-in (Hohenwarter and Lavicza, 2007). GeoGebra can be used on MS Windows computers as well as MacOS computers without any problems. Additionally, all operating systems can run the same version of GeoGebra which prevents delays of software releases for different operating systems as often seen for commercial products (**Preiner, 2008**).

Conclusion

The above section deals with the theoretical background of Geogebra. The historical development, unique characteristic features and how it can be embedded into the modern constructivist educational philosophy is described in detail. The practical aspects of using Geogebra is also illustrated. The above section thus highlights the potential for using enriched virtual environments such as Geogebra for an updated and enhanced teaching learning experience.

Problem Solving Ability

The following section deals with the theoretical background of the variable Problem Solving Ability. Problem solving is a mental process and is part of the larger problem process that includes problem finding and problem shaping. Considered the most complex of all intellectual functions, Problem solving has been defined as higher-order cognitive process that requires the modulation and control of more routine or fundamental skills. Problem solving occurs when an organism or an artificial intelligence system needs to move from a given state to a desired goal state.

Meaning and Definition of Problem Solving

According to Dewey, learning is to think and education is the formation of careful and thorough habits of thinking. A major emphasis of progressive education is the insistence that pupils be asked to think, in other words that pupils be taught to solve problems.

The meaning and nature of Problem solving is further classified by the following definitions.

Woodworth and Marquis (1948). Problem-solving behaviour occurs in novel of difficult situations in which a solution is obtainable by the habitual methods of applying concepts and principles derived from past experience in very similar situations.

Skinner (1968). Problem solving is a process of overcoming difficulties that appear to interfere with the attainment of a goal. It is a procedure of making adjustment in spite of interferences.

Gagne (1965). "Problem solving may be viewed as a process by which the learner discovers a combination of previously learned rules which can be applied to achieve a solution for a novel situation."

Problem solving may range from simple ones to those of high level complexity depending upon the difficulty level of the problem. With the advancement of socio-economic and technological fields, the life of the individual is becoming more and more complex fraught with a number of problems which the individual and the society have to face in the near future. The problem is solved but something new is also learnt. Ability also ranges from individual to individual. Simple problems can well be solved by instinctive and habitual behaviours. More difficult problems require a series of solution attempts. There are some who are able to solve problems sooner than others.

Approaches to Problem Solving

Traditionally two different approaches have been mentioned by psychologists, adhering to two families of learning theories: (a) Cognitive field theory (b) Stimulus-response theory.

Cognitive field theory emphasizes the importance of perception of total situation and relationship among its components, and restructuring the cognitive field. Kohler conducted his classical experiments on Sultan to study the process of Problem solving in animals. He, from his study on Problem solving, proposed that solution of a problem is arrived at, all of a sudden, after some initial efforts by the individual. Many studies have been conducted on children and adults which confirm that solution of a problem is reached, all of a sudden through insight into the situation.

The second point of view has been advanced by stimulus-response theories who emphasize the importance of trial and error. They hold that problem is solved through a gradual process of elimination of errors and putting together correct responses. There has been considerable controversy as regards superiority of one approach over the other as an interpretation of Problem solving. Some psychologists are of the opinion that cognitive field theories approach is most effective for solving problems which require higher mental processes and stimulus – response approach is effective for solving simple problems.

To do away with the controversy of cognitive and stimulus response theorists approach, Harlow 1959, proposed a third explanation. His approach is more realistic and rational in nature. He conducted series of experiments on monkeys and human objects with simple problems of discrimination. He observed that in the beginning his subjects showed trial and error behaviour to solve a series of problems but he noticed that when similar problems were presented to the subjects in future for the first time they made correct discrimination. The later stage appears to be insightful learning, that is suddenly getting the problem solved.

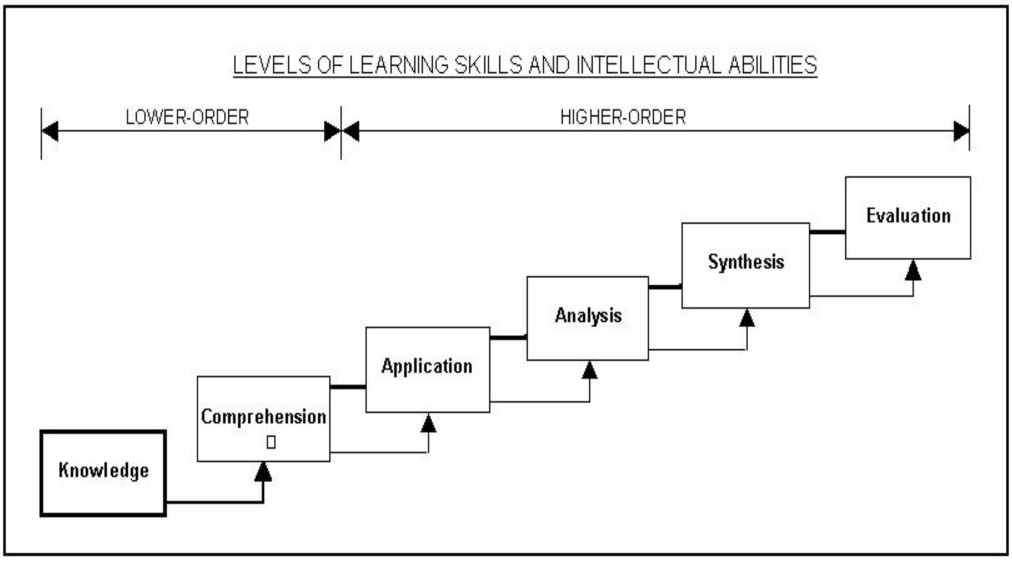
According to Harlow, the underlying assumption is that in the previous trial and error learning, the subjects have learned "how to learn". They acquired what he called a learning set. They acquired method of learning that transferred positively to other problem situations of similar type. Harlow says, "Generalizing broadly to human behaviour, we hold that original learning within an area is difficult and frustrating, but after mastery of the basic facts, learning within the same area becomes simple and effortless."

Levels of Problem Solving in Cognitive Hierarchy

Bloom, Gagne and Piaget are the educationists who have formally developed hierarchy for cognitive problem solving.

Figure 9

Bloom's Levels of Cognitive Learning Skills and Intellectual Abilities



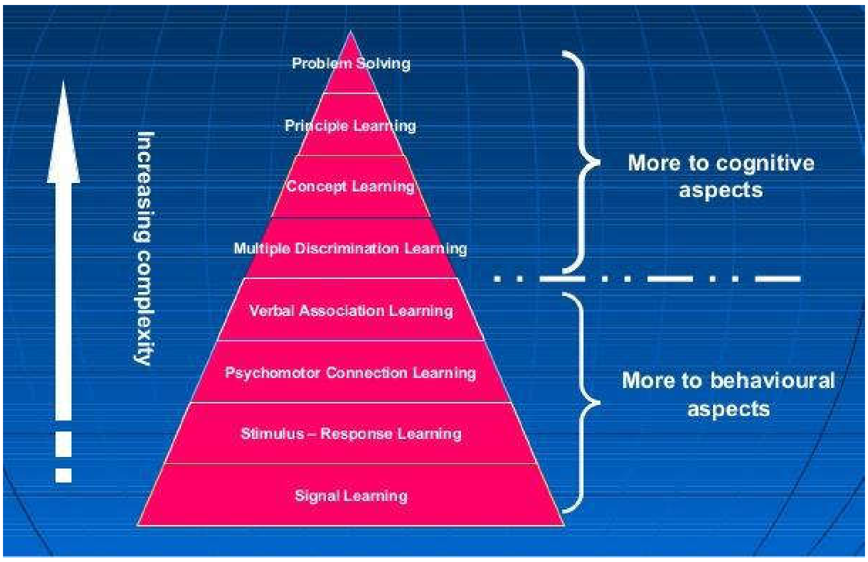
According to Bloom the lowest level of cognitive domain is the recall and recognition of knowledge; followed by comprehension, understanding the material, exploring it more actively; then comes the application of the comprehended knowledge, using the material is concrete application of the comprehended knowledge, using the material in concrete situations. The last stage after the application of their new understanding is an exploration of new stimulations by breaking them down into their constituent elements (analysis) and by building up concepts by synthesis. Finally the highest level of learning is reached on both sides. In the cognitive domain the learners come to evaluate what they are doing, to judge the value of the knowledge. Bloom brings together in his hierarchy of learning process both the cognitive learning and the personal growth element through the affective domain. This synthesizes a marked feature of the third set of learning theories, the humanist group.

Problem Solving in Gagne's Learning Hierarchy

Gagne (1976) attempts to stretch and span the entrances of Pavlovian reflexes and Koehler's Problem solving exercises by postulating a hierarchy of learning. Gagne draws heavily stimulus - response theory. Signal is a generalized learned response to signal received, stimulus – response learning is seen as an advance on this, whereby the stimulus is discriminated out the general background of signals and the response is purposeful. In chaining, the learner connects together two or more stimulus – response reactions. Verbal association is the process of using already learned language to create chains, and multiple discrimination is that from of learning by which the learner makes differentiated responses to stimuli that, although they have a basic similarity, have become distinctive in themselves. A common response to a whole group of stimuli (seen together to form a class) is a concept, while a chain of two or more concepts is the role of principle. Finally Problem solving is the use of principles to select out the required responses in order to resolve a problem and the create a new, higher – level principle.

Figure 10

Pyramidal Structure of Learning Hierarchy by Robert Gagne



Problem Solving in Piaget's Theory of Cognitive Development

Cognitive development is a continuous process that begins at birth. Jean Piaget (2000), a Swiss psychologist divides development into four broad periods. In this order of their occurrence, they are:

1. The sensory for period, 0-2 years
2. The pre-operational period 2-7 years
3. The period of concrete operations, 7-11 years and
4. The period of formal operations, 11-15 years,

The constructs of assimilation; accommodation, adoption and schemata are central to understanding Piaget's conceptualization of development. Assimilation is the psychological process by which the child takes in representations of his environment and his interactions with them. Accommodation is the process by which the individual makes internal adjustments in the existing cognitive structures to integrate the new adoption is the tendency of an organism to maintain equilibrium through the process assimilation and accommodation scheme (pl. schemata) is an organized or logical mental pattern of operation on the external world, or interaction with it. They arise from interactions and form the bases for further operations.

Concrete operational stage (7-11 years) and Formal operations (11 to 15 years). During this period the child becomes capable of applying logical thought to all classes of problems such as verbal problems, hypothetical problems and future problems, with the development of formal operations the child is capable of thinking logically if implies that the capacity for fully logical through is present once formal operations are developed. Initially, an adolescent's use of logic ego centric. In a sense, the adolescent uses logic as the sole.

Criteria on for what is 'good' 'right' 'moral' He tries to reduce the world to what is logical. He fails to differentiate between 'what is logical' and "what is real' in this sense, the adolescent's thought is egocentric logical but not yet fully realistic. Thus, many adolescents appear to be very idealistic in their thinking. Piaget suggests that this temporary or false idealism will change when the adolescents confront the real world. False idealism's a necessary prior development to realistic thought, whether one retains idealism or not.

Problem Solving in Mathematics

Problem solving is an important component of mathematics education because it is the single vehicle which seems to be able to achieve at school level all three of the values of mathematics: functional, logical and aesthetic.

Mathematics is an essential discipline because of its practical role to the individual and society. Through a problem-solving approach, this aspect of mathematics can be developed. Presenting a problem and developing the skills needed to solve that problem is more motivational than teaching the skills without a context. Such motivation gives Problem solving special value as a vehicle for learning new concepts and skills or the reinforcement of skills already acquired (Stanic & Kilpatrick, 1989).

The National Council of Teachers of Mathematics, 1989 recommended that Problem solving should underlie all aspects of mathematics teaching in order to give students experience of the power of mathematics in the world around them. They see Problem solving as a vehicle for students to construct, evaluate and refine their own theories about mathematics and the theories of others.

As education has come under criticism from many sectors, educators have looked for ways to reform teaching, learning, and the curriculum. Problem solving has become the means to rejoin content and application in a learning environment for basic skills as well as their application in various contexts.

One of the aims of teaching through Problem solving is to encourage students to refine and build onto their own processes over a period of time as their experiences allow them to discard some ideas and become aware of further possibilities.

Problem Solving in Geometry

The Southwest Educational Development Laboratory (SEDL, 1995) has remarked that Geometry is an orderly way to describe and represent our inherently geometric world. Basic to the understanding of geometry is the development of spatial sense-an intuitive feel for our surroundings and the objects in them. Children who develop a strong sense of spatial relationships and master the concepts of geometry are better prepared to learn number and measurement ideas as well as other advanced mathematical topics.

Evidence suggests that the development of geometric ideas progresses through a hierarchy. Students first learn to recognize whole shapes and then to analyze properties of shapes. Later they can see relationships between shapes and make simple deductions. Instruction in geometry must consider this hierarchy because, although learning can occur at several levels at once, the learning of more complex ideas requires a firm foundation of basic skills.

For middle school students the informal exploration of geometry can be mathematically productive. Geometry at this level links the informal explorations begun in grades K to 4 to the more formal processes of grades 9-12. Students draw inferences and make logical deductions from geometric problem situations. They can also analyze their thought processes and explanations. Geometry has its own vocabulary including terms like rhombus, trapezoid, and dodecahedron, and students need ample time to develop confidence in their use of this new and unique language. Definitions should evolve from experiences in constructing, visualizing, drawing, measuring, contrasting, and classifying figures according to their properties. Students who memorize a definition and a textbook example or two are less likely to remember the term or its application.

Students should be given the opportunity to work with one-dimensional, two-dimensional and three-dimensional figures so they can develop spatial skills that are basic to everyday life. Visualization also includes plane figures; computer graphics software that allow students to create and manipulate shapes make conjecturing and testing their attempts at two-dimensional visualization easier. (SEDL-SCIMAST, 1995).

Role of Teacher in Problem Solving

Problem solving is an individualized process which requires various strategies to tackle. The class-room teacher can develop a scientific approach to solve problems which the students are expected to face in social life. Tentative suggestions are being given for teachers which can prove useful in developing right attitude to approach a problem (Jonassen, 2000).

Moderate Motivation. It has been pointed out by experimental studies that extreme motivation or excessive emotional involvement is a problem hinders productive thinking. The teacher should create moderate motivation in his students. If he finds that students show high motivation, he should drop the problem and return to it when he finds students in a calmer state but on the other hand motivation should be sufficient to sustain the interest of the class. The teacher can create motivation by utilizing various techniques.

Encourage Divergent Thinking. The teacher should not emphasize confirmatory behaviour in his students. He should encourage divergent thinking in his students. Students should be encouraged to tackle problems in a variety of ways. He should allow flexibility and original approach to problems. Reasoning should be developed through guided discussions in the class.

Problem should be Presented as a Whole. The teacher should present problems in the class as a whole so that students may have the perception of the total situation for the solution.

Level of Difficulty. The teacher should see that the problems are not too difficult for the class. He should keep in mind the maturation level and the level of developmental task to create motivation in the students. The problem should be neither too difficult nor too easy for the class. The problem should create a moderate level of anxiety in the students.

Active Manipulation. The teacher should present a problem in a planned way. He should get the active involvement of the class in the process of solving a problem. Use of diagrams, figures and manipulation of concrete material should be made to conceptualize the abstract problems. The teacher can shift the functional properties of objects by verbalizing the characteristics of words, objects, plan or act and then evaluate the environment in these terms.

Practice. Teacher should give practice on problems of a great variety to develop proper mental set in his students to solve similar types of problems in future.

Incomplete Solution. It has been proved that incomplete tasks are retained more than complete. The implication of this is that teacher should never provide complete solutions to problems. Some unanswered questions should be left for the students for solution. The teacher can develop the spirit of formulating tentative conclusions of the problem. He should make an effort to develop scientific attitude.

Activities for Problem Solving

Wu et al. (2012) suggests a number of activities to promote problem solving in Mathematics. Some of them are,

(1) Through Models. Model means a replica. The educational tools which are constructed for the content of mathematics are called mathematical model. Different models related to a problem of mathematics can be made and given to students, and a Problem Solving program can be organized. A model gives an idea about what does the problem want to say. Students can be given knowledge on how to make such models. Certain models are such that they can be used to bring solution in different ways by the students. For e.g. the model of $(a \pm b)^2$, the model of $(a \pm b)^3$, En^2, En^3.

(2) Through Computer. A problem on various problems is made and stores in a computer to provide knowledge of various problems to children.

Then the students are asked to find solution of a problem on a computer. The students try to find solution on a computer. Currently there are certain websites having such mathematical problems for e.g. planet. Mat.

(3) Through Games. Currently, many mathematics related problems have come into existence and various games have been produced which are related to these problems. Such as magical square, fill the squares, etc. Thus students can be given knowledge through recreation.

(4) Through Group Work. A group of 5 to 7 students can be formed. Similar groups can be formed and various mathematical problems can be given to each group. The students will collectively try to find solutions of problem of their respective group. With the help of this activity certain characteristics of association and cooperation can be developed among the students.

Conclusion

The above section deals with the psychological studies dealing with problem solving including Kohler's cognitive field theory experiments and stimulus response experiments of trial and error learning followed by Harlow's views of insightful learning. The Hierarchy of levels in cognitive learning as proposed by Bloom, Hierarchy of Gagne and the stages of cognitive development by Piaget. Problem solving in Mathematics in general and Geometry in particular and role of teachers and how activity centred learning can help is also discussed.

Review of Related Studies of the Variables

The following section attempts to review studies related to the variables of the study, Virtual Learning Environment, Geogebra and Problem Solving Ability. The review of studies gives an opportunity to explore the various aspects of the variables involved in the study and aids to summarize and synthesize past findings and to notice any research gap in the area.

Review of Related Studies on Virtual Learning Environment

This section presents some of the pertinent studies conducted in the area of virtual learning environment.

Zwart and Goei (2021) studied the potentiality of computer-based virtual learning environments (CBVLEs) as useful teaching tools for training nursing students in professional duties such as the mathematical tasks associated with medication processes which included well-structured instructional activities with interleaved practice and feedback in a sample of 118 nursing students enrolled in bachelors and post-secondary nursing programmes. The study reveals the advantage of technology mediated learning and also indicates hoe technology benefits low achievers especially when it comes to aiding remote learning.

Santos and Netto (2020) designed an animated pedagogic agent. This was further integrated to a Moodle virtual learning environment, and researched upon by assisting tutors in implementing them to accompany students. Students emotional and motivational states were also explored. The results obtained clearly indicates the positive effects of virtual learning environment in contrast to the traditional teaching learning process while simultaneously knowing the emotional state of students.

An article on Mind the Gap: Cognitive Active Learning in Virtual Learning Environment Perception of Instructors and Students authored by Annansingh (2019) details the use of virtual learning environment as increasingly gaining popularity with universities among students and instructors as it can increase the flexibility and promote independent learning. This paper explores the disparity between students and the instructor's perception of cognitive active learning experience in a VLE. Consequently, this paper utilizes a phenomenological constructivism approach by using interviews and questionnaires as the primary method of data collection. The results show that instructors believe students are often not intrinsically motivated and consequently do not automatically experience deep learning in the VLE without the appropriate instructional support. The instructor must stimulate deep thinking with a well-formed and probing questions or comments which promotes critical thinking and knowledge transference. This highlights the disconnection between the two instructors and learners in the expectations, attitude towards learning, and the learning environment.

Khlaisang and Songkram (2019) examined the necessary factors for developing an effective virtual learning environment (VLE) system and to examine its effectiveness with the aim of enhancing the range of twenty-first century skills of higher education students in the Association of Southeast Asian Nations (ASEAN) community in 400 higher education instructors. The findings were positive and supported by the results of behavior and trace observations and project assignments. The paper in addition enlists the 7 elements of the VLE system and 7 steps involved in its development.

Dommett (2019) published an article on Understanding the Use of Online Tools Embedded within a Virtual Learning Environment. Different learning tools are available within virtual learning environments, including forums, quizzes, and ePortfolios. This article investigates perceptions of helpfulness and ease of use of these three tools, including how they are impacted by learner characteristics and what predicts frequency of use of each tool. Critically, the relationship between perceived helpfulness of the three tools and their ability to support achievement of learning outcomes and development of employability skills is assessed. The findings support previous work showing an impact of learner characteristics on perceived helpfulness and ease of use for all tools. Results also show that the ability of forums to support achievement of learning outcomes predicts their perceived helpfulness, whilst development of employability skills predicts helpfulness of quizzes. In turn, helpfulness but not ease of use predicted frequency of these tools.

Farooq and Benade (2019) also conducted a review of literature on Constructing a Dialogic Pedagogy in Virtual Learning Environments. The study aimed to understand how online educators picked cues from the discussion platforms offered by virtual learning environments to critically reflect on their pedagogical practice, and the associated changes they made to help students achieve their learning outcomes. It critically assessed how dialogic pedagogy and critical reflection can be adapted to fit in the framework of virtual learning, and contrasted these philosophical ideas to the Western criticism of automation and de-professionalisation of universities in the wake of increased distance learning options provided by tertiary institutes. The findings were discussed within a post-intentional phenomenological framework. In what follows, significant literature that illuminates this question has been critically analysed.

The study on Navigating the Shortcomings of Virtual Learning Environments via Social Media by Murugaiah and Yen (2019), reinforces that it is undeniable that the higher education landscape worldwide has changed with the emergence of virtual learning environments (VLEs). These systems offer learning space and resources for teachers and students regardless of time and place. Although they significantly contribute to the achievement of learning objectives and outcomes, their usage is generally limited. This article uncovers the shortcomings of the use of VLEs for language learning in several Malaysian institutions of higher learning and highlights the use of social media in addressing the barriers. Adopting a qualitative approach, data were gathered via in-depth interviews. Employing the dimensions proposed by Chun, Kern and Smith, the hindrances related to VLEs were examined. The findings revealed that instructors faced obstacles linked to the technology, students' experience and expectations as well as language learning environment. Social media helped them in addressing these obstacles.

Santoianni and Ciasullo (2018) studied on Adaptive Design for Educational Hypermedia Environments and Bio-Educational Adaptive Design for 3D Virtual Learning Environment which has been recently re-shaped by the bio-educational adaptive approach which designs VLE considering learners' individual differences. This research tries to the questions of adaptation by describing Federico 3DSU, an educational University 3D Virtual Learning Environment which has been designed with adaptive criteria, according to bio-educational model.

Vogel et al. (2018) presented a paper on Tacit Knowledge in Virtual University Learning Environments. The report mentions that knowledge work has become a major component of value creation, especially in industrialized countries.

Processing knowledge in virtual ways becomes increasingly possible with emerging technological innovations. Transmition of elusive tacit knowledge in a virtual setting remains an important unanswered question. Education at universities benefits from the use of virtual environments for passing on knowledge, such as by setting up MOOCs and using learning apps. Knowledge management and processes are being widely analyzed but research on harvesting tacit knowledge in virtual educational environments is still rare, in particular regarding the use of intelligent tutor systems for knowledge management processes. Hence, the paper addresses the central question of how university knowledge processes concerning tacit knowledge can be supported by intelligent systems, such as bots and tutor systems.

Dayag (2018) writes on EFL Virtual Learning Environments: Perception, Concerns and Challenges. The author opines that sustaining VLEs is not an easy task as it raises various concerns and challenges, particularly in the domain of EFL (English as a Foreign Language) learning. This paper reports on the results of a qualitative study aimed to shed light on the stakeholders' perception towards VLE as well as the significant concerns and challenges encountered by EFL lecturers and their students on their actual use of VLEs in a higher education institution. Furthermore, the study unveiled the practical tips to create efficient and effective VLEs, based on the suggestions of both the EFL students and their lecturers.

Borba et al. (2018) published an article on Interactions in Virtual Learning Environments: New Roles for Digital Technology. The article mentions that for the last 10 years, online pre-service teacher distance education has increased significantly in Brazil. As a result, research on this educational modality has also increased, in particular, research investigating the different roles students and teachers play in these courses. The purpose of this paper is to analyze the role of digital technologies in two specific contexts: how teachers, tutors, and students play a role in producing interactive digital didactic material and how digital technologies themselves can play a role in teaching distance learning courses. But for these roles to emerge, we point to the need for participants of online courses to interact collaboratively. To identify these roles, grounded theory, a branch of qualitative research, was used as the two roles were articulated. Data were produced from virtual observations in virtual learning environments and virtual interviews. The results stress that both highlighted roles are related. They transform teacher and student roles and participation in the virtual classroom, and an "agency of media" emerges in online mathematics education.

Alves and Miranda (2017) conducted a quantitative study which focused mainly on the relation between the use of a virtual learning environment (VLE) and students' performance from a public higher education institution during the academic year of 2014-15 in a sample of approximately 6,300 undergraduates. The results reveal that there are positive indicators regarding students' access to a virtual learning environment and also in relation to the access and their performance.

In a study by Zacharzuk-Marciano (2017) on Nursing Faculty Experiences of Virtual Learning Environments for Teaching Clinical Reasoning, the qualitative study identified and described nursing faculty experiences with teaching clinical reasoning skills when using virtual learning environments. Eight nursing faculty were interviewed and the transcript were analyzed. Findings from this qualitative study indicated that virtual learning environments included patient situations that offered faculty a way to better assess students. Faculty experiences indicated that one of the challenges to teaching clinical reasoning skills with virtual learning environments was that students found that virtual communication was difficult and faculty claimed that using virtual environments increased faculty workload. The findings of this study provided deeper understanding into experiences reported by nursing faculty on the teaching of clinical reasoning skills when using a virtual learning environment.

Adams (2017) studied The Knowledge Development Model: Responding to the Changing Landscape of Learning in Virtual Environments. The report mentions about the dynamic face of knowledge and that effective teaching models focused on leveraging strategic control of the knowledge from teachers to learners in virtual learning environments are critical to insure a positive path. The Knowledge Development Model serves as the guide for determining how to move learners through stages of knowledge acquisition to knowledge application and ultimately to knowledge generation in virtual settings. Instructional strategies for fostering student engagement in a virtual learning environment are identified as critical, and a number of relevant theories focusing on student learning, affect, needs and adult concerns are presented to provide a basis for transfer of knowledge from teacher to learner.

Choi and Walters (2017) presented a paper on Does Self-Reflection Matter for Math Performance in a Virtual Learning Environment? The report mentions that engaging students in self-reflection about their learning performance is a potentially promising pedagogical approach for supporting math learning. However, it is unclear how models for math learning in regular classrooms translate in a virtual environment. The purpose of the paper is to (a) analyze rich assessment data from virtual schools to explore the association between self-reflection and math performance, (b) compare the patterns found in student self-reflection across elementary, middle, and high school levels, and (c) examine whether providing opportunities for self-reflection had positive impact on student learning in a virtual learning environment. Implications for future research in this area are provided.

In a study by Reisoglu et al. (2017) on 3D Virtual Learning Environments in Education: A Meta-Review, 167 empirical studies that involve the use of 3D virtual worlds in education were examined. The findings mention that case study designs and quasi-experimental studies were more common. Sample sizes were below 100 for most studies. 3D virtual learning environments are mainly designed for learning support, simulation, and game. Language learning and science have been the most extensively studied topics. Collaborative and exploration-based learning strategies have been used most frequently in 3D virtual learning environments. Presence, satisfaction, communication skills, and engagement were examined as emotional and cognitive achievements.

Scott et al. (2017) has reviewed literature on Adaptive 3D Virtual Learning Environments. The report mentions that many Virtual Learning Environments have been widely adopted by educators, obtaining promising outcomes. Recently, these environments have evolved into more advanced ones using 3D technologies and taking into account the individual learner needs and preferences. This focus has led a shift to more personalized learning approaches, requiring that the environments adapt themselves to the learner. Then, many adaptive 3D environments have explored adaptive features to create new and enhanced learning experiences in different contexts. However, very little is known about both what factors are involved with adaptive 3D environments to achieve learning benefits and what assessment factors are present in current studies. For this reason, this review analyzes the recent publications on Adaptive 3D Virtual Learning Environments. Findings have revealed that these environments have covered factors on defining the learner's model, the instructional strategies and contents, and the adaptations mechanisms. Nearly half of the environments have addressed thorough assessments whereas the rest has not reported any evaluation at all. Moreover, when they report assessment, promising outcomes have also been shown not only in multiple domains of knowledge but also at various stages of education. These findings indicate that the field of Adaptive 3D Virtual Learning Environments is an active and ongoing area, and this study highlights several promising directions and suggestions for future research.

Khorshidi and Peterson (2016) conducted a study on Virtual Learning Environment for Interactive Engagement with Advanced Quantum Mechanics. The study reveals how a VLE can engage university students in the learning process in ways that the traditional lectures and lab formats cannot. The VLE incorporated simulations, multiple-choice quizzes, video lectures, and gamification into a learning path for quantum mechanics at the advanced university level in 47 students. Increased learning in students who were more active on the platform independent of their previous performances were found.

Demirer and Erbas (2016) published an article on Trends in Studies on Virtual Learning Environments in Turkey between 1996-2014 Years: A Content Analysis. 63 studies consisting of thesis, articles and proceedings published in Turkish and English between the years 1996-2014 were analyzed. It was observed that "Second Life" was mostly preferred as the virtual learning environment. Literature review and quantitative research methods were mostly preferred in the studies respectively. Most of these studies used surveys to collect the data and sample size in most studies was between 31-100 participants. Mostly, participants were undergraduate students, and purposive and convenience sampling method were preferred in the studies. The data was mostly analyzed using quantitative descriptive analysis method. The most studied variable was academic achievement and the least one was the cognitive load. The studies yielded varying results owning to their study purposes and showed that virtual learning environments fostered student academic success, diminished the cognitive load by concretizing the concepts and ensured social and collaborative learning. The findings of this study benefits researchers aiming to employ virtual learning environments in their educational studies.

Liew et al. (2016) conducted a study on The Effects of a Pedagogical Agent's Smiling Expression on the Learner's Emotions and Motivation in a Virtual Learning Environment. The study aims to test the hypothesis that a smiling expression on the face of a talking pedagogical agent could positively affect a learner's emotions, motivation, and learning outcomes in a virtual learning environment. Contrary to the hypothesis, results from the first experiment demonstrated that the pedagogical agent's smile induced negative emotional and motivational responses in learners. The second experiment showed that the social meaning of a pedagogical agent's smile might be perceived by learners as polite or fake. In addition, qualitative data provided insights into factors that may cause negative perceptions of a pedagogical agent's smile, which in turn lead to negative affective (emotional and motivational) states in learners. Theoretical and design implications for pedagogical agents in virtual learning environment are discussed in the concluding section of the paper.

Hazari and Sandra (2015) conducted an investigative study on Factors Affecting Group Processes in Virtual Learning Environments. The study mentions the challenges relates to creating and managing group projects and investigated business students' perceptions of group work in online classes. The constructs of learning and social interaction, process satisfaction, product satisfaction, and use of technology in the virtual learning environment were investigated. The use of social media networks by group participants was also examined. Recommendations are provided for business educators looking to develop or enhance teamwork in virtual learning environments.

A study on Authoring Adaptive 3D Virtual Learning Environments was conducted by Ahmed and Olga (2014). The report elucidates on how the use of 3D and Virtual Reality is gaining interest in the context of academic discussions on E-learning technologies but also with some drawbacks. An adaptive learning environment that dynamically adapts to the learner and the activities that he performs in the environment can help overcome this drawback. The authors also discuss an adaptive 3D virtual learning environments and explain how a course author can specify such an environment by authoring. The authors also conducted an evaluation to validate the approach and the usability and acceptability of the authoring tool and recommendations for authoring adaptive 3D virtual learning environments have been formulated.

A study has been conducted by Mogus et al. (2012) on The Impact of Student Activity in a Virtual Learning Environment on Their Final Mark. The aim of this research is to examine data (activity logs) obtained by students' while they are logged into the virtual learning environment in order to detect frequencies and priorities of students' choice of activities in a virtual learning environment. The activity logs are used to measure students' effectiveness of learning to determine whether students' activity logs, within courses supported by a virtual learning environment as part of a blended learning approach, correlate with their final marks and the students' perceptions of using the virtual learning environment. Observed activities involved course view, assignment view, resource view, forum view, assignment upload and project upload when seen against their final mark. Data log features of a virtual learning environment and an instrument used to gather data on the students' perceptions of using the virtual learning environment were used. Results show that there are positive correlations between students' logs of particular activities and their final mark.

Review of Related Studies on Geogebra

The following section deals with the review of studies conducted on Geogebra.

Zelrijuslita and Endang (2021) carried out a mixed-method study to identify improvements in Self Efficacy and self-regulated through GeoGebra Based Teaching to students of mathematics education department at the Islamic University of Riau. The study revealed an increase in self-efficacy and self-regulated through GeoGebra based teaching from both high, medium and low level.

Yorganci and Serpil (2020) explored views of graduate students on mathematics learning with GeoGebra by case study method of 7 graduate students in a state university at Turkey. The findings show that "visualization", "ease of use" and "rich content" themes play a key role in the clarity of "motivation" theme. Also, the construction protocol and the text tool are effective in gaining the skills of algebraic thinking, while the construction protocol, visualization and concretization features are effective in their conceptual learning. "Simulation" and "content" prominently make effective the use of GeoGebra in mathematics courses.

Radovic and Radojicic (2020) designed an interactive learning textbook (eBook), created with GeoGebra applets. Students who have used the interactive eBook show statistically significant increased knowledge and knowledge retention compared to students who have attended the standard classes and also emphasized that tasks with interactive applets and new kind of learning materials inspired them to learn more, both in school and at home.

Weinhand and Schallert (2020) conducted an explorative educational study aimed to identify how learning settings and learning environments should be designed to facilitate synthesising flipped approaches to education using GeoGebra at a

Viennese secondary school .Qualitative analysis of data indicates that the categories (a) clear task definition and task design, (b) feedback, (c) context and benefits, and (d) single-source learning environments are effective and recommendable for pupils while implementing GeoGebra for enhancing flipped education.

Ljajko (2016) investigated whether problem complexity has any impact on the Mathematics achievement of students when taught through computer aided instruction using GeoGebra as an experimental study implementing three tests to assess the achievement decay rates. The sample was selected from third grade students (6-7 years old) from Serbia. The results showed that the GeoGebra group students scored better than the control group. This indicates instruction using Geogebra helped students perform with improved efficiency in solving complex mathematical problems.

In a study by Puteh and Rahman (2016) on the impact of GeoGebra learning module on under achievers in sample of 47 students in Malaysia, analysis of results indicates that GeoGebra has the potential in improving the achievement and provide motivation to the students. The study thus recommends the use of GeoGebra in Mathematics instruction.

Bakar et al. (2015) conducted a study on the effects of using GeoGebra on students' performance to the traditional classroom instruction on a Geometry topic by a quasi- experimental post-test-only control group design in secondary students in a Malaysian school. The results analysed by independent sample t-test analysis reveals that students exposed to GeoGebra achieved significantly better test scores as compared to the control group. Thus, integration of GeoGebra in the teaching and learning of geometry is beneficial and its use should be enhanced.

Bhagat and Chang (2015) studied the effect of GeoGebra on Mathematics achievement of 9th grade students from eastern part of India. The quasi-experimental study revealed that GeoGebra is a very effective tool in strengthening the Mathematics achievement of students and suggests that GeoGebra should be integrated into Mathematics teaching and learning in India.

Aydos (2015) studied the impact of GeoGebra on students' conceptual understanding in limits and continuity and attitudes toward learning Mathematics through technology in 34 gifted and talented high school students in Turkey. The results of the study also showed that GeoGebra as opposed to traditional teaching helps to improve student attitudes toward learning Mathematics through technology.

Kushwaha et al. (2014) conducted an experimental study on the impact of GeoGebra on students' achievement in Mathematics on 80 students from 9^{th} grade. The data analysis revealed that GeoGebra has a meaningful impact on students' Mathematics achievement.

The study conducted by Shadaan and Eu (2013) revealed that GeoGebra is an effective tool in improving the achievement of students in the topic circles and that students perceived GeoGebra as a powerful tool in understanding mathematical concepts.

May (2013) studied whether GeoGebra as a tool helps secondary school students in enhancing their higher order cognitive skills mentioned in Bloom's taxonomy. The results showed that all students except one were able to reach higher order thinking skill with reference to cognitive level in Bloom's Taxonomy after learning Mathematics with the help of GeoGebra.

Mukiri (2012) conducted a study in secondary schools of Kenya following the mixed method design to assess the applicability of GeoGebra in the teaching of

Mathematics. The results throws light upon how GeoGebra helped the students in comprehending abstract ideas and led to improved performance of the students in Mathematics achievement test. The study also showed that even though the teachers were positive about the benefits of GeoGebra, many were actually reluctant to use it in their instruction.

Udi and Radakovic (2012) explored the use of GeoGebra and how it affected critical thinking skills for supporting high school students' understanding of Mathematics in the topic probability. It was clear from the results of the study that the dynamic feature of the GeoGebra applet helped the students to understand the connection between the base rates and conditional probability. The dynamic visualizations of GeoGebra helped them for the deeper analysis of Mathematical concepts. Based on the results the researchers concluded that GeoGebra and critical thinking skills can be used as reflective tools to develop student understanding of probability.

Zengin et al. (2011) conducted a study in Turkey high school students and proved that GeoGebra is very much helpful in learning even the difficult topics of Mathematics and even better than the constructivist approach.

In an experimental research conducted by Budai (2011) it was found that students who learned introductory geometry, geometrical constructions and geometric transformations with the help of GeoGebra performed better than the control group students who learned the same topics using traditional tools. While using GeoGebra in Mathematics learning, students use two different device types such as ruler-compass and GeoGebra. So they have the opportunity to clarify the elementary steps of geometrical constructions in a more confident way.

Reis and Gulsecen (2010) studied the effect of the use of GeoGebra in Mathematics education among sixth grade students in Turkey. The students in GeoGebra group reported to have used more sense organs in learning and that learning is more permanent than traditional method of learning.

Reis (2010) examined the role of GeoGebra in learning concepts of Mathematics. In the experimental study, two homogeneous groups were formed and one group was taught using GeoGebra and the other group was taught using traditional teaching method. It was found that better results are achieved by the group which had been taught using GeoGebra and also that many students failed to understand the subject at the minimum anticipated level with traditional teaching method.

Rahman (2016) investigated the influence of GeoGebra assisted learning on creativity in students of Jakarta. The result revealed that students who received GeoGebra assisted learning had better creative thinking ability than students taught in traditional strategies.

Rodrigues (2015) studied Mathematics creativity and Geogebra in teaching of algebra in Portugal in a class of 16 students of the ninth grade. The results revealed that learning experiences through GeoGebra contributed to the development of concept understanding of participants on creativity in general and on Mathematics creativity in particular.

Granberg and Olsson (2015) studied how GeoGebra supports students' collaboration and creative reasoning during mathematical problem solving. The results obtained after analysis of the conversations and the computer activities of students show that GeoGebra provides a common space for sharing thoughts and creative feedback which can enhance individual creative reasoning. Thus, GeoGebra supports collaboration and creative reasoning of students. In a similar study by Rumanova and Smieskova (2015) about creativity needed for geometric tasks designing, visualization of geometric problems and use of Geogebra among pre service teachers in Slovakia also revealed that GeoGebra supports students' creative thinking.

Coelho and Cabrita (2014) checked the impact of Dynamic Geometry Environments (DGE) using GeoGebra on developing creativity and on understanding of geometric concepts and skills among three groups of fifth grade students (one group consisting of one student and two groups consisting of two students). This approach has been found to have a major influence in developing creativity, also if combined with paper and pencil environments, was more beneficial for the development of geometric knowledge and skills.

Olsson (2014) in a study tried to find out the causes and consequences of different use of GeoGebra while solving mathematical tasks. The study revealed that the interactive features of GeoGebra guides creative reasoning of students and also it provides feedback to the students. The study also showed that students who have higher creative reasoning ability utilize the feedback from GeoGebra elaborately and the students who have lesser creative reasoning ability use the feedback from GeoGebra for just verifying their results. The results of the study revealed the importance of leaving the responsibility of creating solving methods to the students.

The impact of using computers on mathematical creativity was examined by Hautz (2013). The capacity of the pupils to pose new questions regarding uncharted territory was emphasised. The students were given access to a task that had been designed for them to complete. The pupils were given the same task twice, once using paper and pencil and once with GeoGebra. After finishing their work on paper and pencil and again after finishing their work on GeoGebra, the students were instructed to pose as many questions as they could concerning the scenario. It was determined through analysis of the student responses that GeoGebra has a beneficial effect on pupils' mathematical creativity.

Furner and Marinas (2016) offered a practical response to a pressing problem affecting students. Leung and Lee (2012) did a study in Hong Kong to identify the learners' geometrical perceptions in a dynamic geometry platform using GeoGebra. The kind of knowledge a student attains in the world of dynamic geometry depends on how he/she experiences the dynamic geometry environment. The student perceptions were measured with the help of a task perceptual landscape which gives a visual planer density complex that represents students' perceptions. The results of the study implied that task perceptual landscape has potentially rich implications on pedagogy.

Zakaria and Lee (2012) conducted a quantitative survey among Mathematics teachers of Sabah to know their perception toward the use of GeoGebra. Four workshops were conducted to familiarize GeoGebra to the teachers before collecting their perception about the software. It was found from the analysis of the data that teachers had a positive attitude toward the use of GeoGebra in Mathematics learning. According to the participants, use of GeoGebra helps the students to learn without boundaries and help the teachers to facilitate students' understanding of Mathematics concepts.

According to Lopez's (2011) research, introducing GeoGebra into math classes can be a successful strategy for fostering mathematical attitudes and skills among secondary pupils. The study's findings demonstrated that most students' attitudes toward mathematics improved as a result of using GeoGebra. The study also demonstrated the effectiveness of GeoGebra as a tool for enhancing visualisation process competencies.

Through a study conducted among secondary school students, Chacon (2011) attempted to pinpoint the factor, attitudes, that are involved in the successful integration of GeoGebra in the mathematics teaching and learning process. The study's findings suggested that GeoGebra's use in technology-assisted teaching and learning greatly impacts the attitudes of students.

GeoGebra was used to conduct a qualitative study by Mainali (2014) in a Nepalese high school. The study's goal was to introduce GeoGebra to the students. Reflection and rotation were covered in a GeoGebra lesson. GeoGebra was used to give students the chance to understand and investigate the subject further. After the computer work sessions, the students were interviewed. According to the pupils' replies, GeoGebra assisted them in visualising mathematical ideas. They discovered GeoGebra to be an excellent tool for learning mathematics since it gave them a thorough comprehension of the taught ideas.

A study of middle school students' work in dynamic geometry environments (DGE) in Sweden and India was done by Lingefjard et al. (2012) to understand whether a DGE can help the process of making conjectures and whether this process reflect on the way students perceive proof using GeoGebra. The study reveals that constructing geometric figures and working on them in a DGE, students can easily reach at the proof of the theorems by themselves. Students in both the countries appreciated the experience of learning Mathematics in a DGE using GeoGebra.

Mehanovic (2011) investigated the advantages and disadvantages of using GeoGebra in upper secondary math classes. The introduction and integration of GeoGebra were examined from both the teachers' and students' perspectives.

According to the study's findings, it was challenging for students to apply GeoGebra in their learning when they had poor problem-solving skills. Lessons became more challenging because to GeoGebra. However, students who had good work habits made use of GeoGebra's capabilities to grasp the idea. All of the study's participant kids agreed that learning how to solve problems using paper and pencil is more crucial than learning how to utilise GeoGebra. Despite the fact that the instructors discovered GeoGebra to have a significant didactic potential in teaching integrals, several of Choi (2009) did a study in Korea about the use of GeoGebra in Mathematics classroom of gifted students. According to the study the obstacles of using GeoGebra in the classroom as pointed out by the teachers include lack of familiarity of students about the features of GeoGebra, constraints in selecting topics suitable for GeoGebra and the students are more interested in operating GeoGebra than solving problems. But GeoGebra implementation was in the beginning stage in Korea. So the researcher hopes that these problems would be solved soon as technology develops. Based on the results of the study a dynamic geometry software must be easy-to-use, familiar with teachers and students and it should be possible to use with practical instruction materials in the Mathematics classroom.

Students enrolled in the foundation studies programme for science and engineering were first taught to GeoGebra by Green and Robinson (2009). In the initial sessions, GeoGebra's fundamental functions were shown. The concepts of equations and functions, graphs of functions, and differentiation using GeoGebra were covered over the course of three sessions. A questionnaire was used to get feedback from the staff and students regarding GeoGebra after the sessions. They claim that GeoGebra's advantages include its simplicity, ability to link algebra and geometry, ease of drawing function graphs, dynamic nature, sliders, and reflection for inverse and symmetries. The absence of any intermediate algebraic operations is

GeoGebra's fundamental flaw. The study shown that GeoGebra can be utilised for higher education even if it was created for secondary mathematics.

In his 2009 study, Davoodi examined how using GeoGebra affected students' comprehension of the slope concept. To achieve the study's goals, a case study involving five 8th and 9th grade students was conducted. After carefully examining the working sessions with the dynamic geometry software and the responses of the students who had been surveyed both before and after the implementation of GeoGebra, it was determined that the use of GeoGebra-based activities had improved the students' understanding of the concept. Through these exercises, they were able to transition easily between the three different graphical, algebraic, and tabular representations of functions.

With the use of the GeoGebra and Wink software, Karadag and McDougall (2008) integrated technology into mathematics teaching and learning and examined the impact of this on students' problem-solving techniques. In Ontario, the study involved high school students. The frame analysis method was used to evaluate the acquired data. The study's findings demonstrated how the use of technological tools in mathematics instruction and learning enhanced students' capacity for efficient mathematical problem-solving.

In his post, Cooper (2014) shows how to use GeoGebra to simplify and explain fractions to pupils, one of the most difficult concepts in early mathematics. To interact with the concept of equivalent fractions, GeoGebra applets were created.

GeoGebra resources were created by Cruz and Contreras (2014) to examine quadratic equations as the product of two lines. With the use of locus in GeoGebra, the quadratic expression of the parabola was investigated as the product of two lines. Students can locate the focus and directrix of the parabola once it has been constructed. Students can thus relate the characteristics of lines to those of parabolas with the use of GoGebra. The conceptual knowledge of the subject will improve as a result of this strategy.

Alves (2014) tried to visualize the behavior of infinite series and complex power series with GeoGebra by preparing materials to observe the relationship between the series and the improper integral and to explore the numerical behavior of the series and the growth/degrowth of partial sums.

Miller (2013) shows students how to use GeoGebra to formally test the generalisation of a specific cubic polynomial condition to higher degree polynomials in his work. In terms of its n-1 zeros, the article explains how to use GeoGebra to find the nth zero of an nth degree polynomial. At the point where the abscissa is the mean of three of those zeros, a tangent drawn to the curve of a fourth degree polynomial with four real zeros will cross the horizontal axis at the other zero. A demonstration of how to check this property for a fourth degree polynomial is provided, along with a step-by-step explanation using screenshots from GeoGebra. Additionally, a fifth degree polynomial example is provided for students and instructors.

GeoGebra was used in the development of digital instructional materials by Triantafyiiou and Timcenko (2013) for mathematics instruction at the undergraduate university level in Denmark. For the study, a participatory design approach was used. The interrelationships between the subjects might be explored by the students using GeoGebra applets that were created in collaboration with the professors. The issues that teachers and students had when utilising these applets were discussed in focus groups with students, and classrooms using them were observed. These reflections led to the preparation of modified GeoGebra applets for undergraduate students.

Through their essay, Furner and Marinas (2013) demonstrated how GeoGebra and photography may be combined to improve knowledge of mathematical ideas. This method can be used to connect mathematical issues to issues in the outside world. With the aid of images added to the GeoGebra software, many mathematical concepts, including measurement and numerical relationships, numerical relationships for size comparison, spatial sense ideas, algebraic concepts, angle measurements, measurement for distance and area, Pythagorean Theorem, system of equations, etc., can be taught in relation to the real world. For primary school pupils, this approach will provide a solid foundation in geometry, algebra, and measurement.

Guncaga and Majherova (2012) discussed a number of applications for GeoGebra in the classroom. The creators claim that GeoGebra increases pupils' motivation and curiosities.

GeoGebra worksheets for teaching the topic of symmetry in analytic geometry to secondary pupils were created by Akkaya et al. in 2011. Worksheets for learning line and point symmetry were created, and the processes for creating the worksheets were made very apparent. Under the supervision of their professors, the kids can utilise these. This will improve the pupils' ability to understand the notion of symmetry by assisting them in visualising it.

The authors of Kagizmanli et al. (2011) created tools to teach lines in analytic geometry, a subject that most students find challenging. GeoGebra was used to prepare the instructional materials. Students can have a good understanding of the topic lines by utilising these GeoGebra exercises to master them.

In their article from 2008, Hohenwarter et al. discussed GeoGebra's uses in high school and college calculus instruction. Different calculus examples, such as the slope function of sin (x), derivatives, upper and lower sums, etc., are used to demonstrate how GeoGebra may be utilised to teach calculus. These GeoGebra worksheets can be used by teachers as presenting aids in the classroom or by students as a resource for mathematical experimentation. The post also includes student reactions on learning calculus with GeoGebra. The dynamic and interactive GeoGebra resources were deemed to be beneficial by students for understanding and visualising underlying mathematical principles.

To determine the impact of a GeoGebra-assisted education on mastery of the topic definite integral, Tatar and Zengin (2016) performed a study among aspiring secondary mathematics teachers in Turkey. According to their analysis of the research data, GeoGebra helps make teaching the definite integral topic successful. According to the participants, utilising GeoGebra to teach and learn mathematics creates an engaging atmosphere, offers visuals, and presents opportunity for students to practise and exercise their mathematical skills. Additionally, they claimed that GeoGebra discourages memorization by promoting conceptual learning.

The professional development programme for fifteen math instructors in Nepal using GeoGebra was examined by Mainali and Key in 2012. The teachers came to the opinion that GeoGebra was really useful and helpful in providing conceptual knowledge and meaningful learning for pupils after a four-day training workshop with an emphasis on the programme. It presents actual mathematical ideas and helps people remember them for a longer period of time. The programme assisted the teachers in understanding mathematical ideas and in practical math instruction. According to the study's conclusions, teachers require more technical training in order to successfully implement GeoGebra in their classrooms.

Bulut and Bulut in 2011 conducted research on how pre-service Turkish math teachers used GeoGebra to teach and master mathematical concepts.

According to the opinions of the study's participants, GeoGebra gives them the chance to build their mathematical knowledge in various ways, it helps integrate images into worksheet backgrounds so that geometry can be connected to real-world examples, and it enables teachers to use GeoGebra in mathematics classes to give students a discovery-based learning environment.

In 2010, the researchers Bu et al. conducted a study on the integration of GeoGebra into professional development for rural in-service elementary teachers. For eight weeks, 27 in-service teachers took an online professional development course on solving mathematical problems. The study's conclusions showed that using GeoGebra helped in-service teachers dramatically improve their pedagogy, curricular awareness, attitudes, and knowledge of mathematics. These results support the use of GeoGebra in professional development programmes that aim to improve in-service teachers' comprehension of mathematical large ideas and further equip them with the pedagogical skills they need to make changes to their teaching methods.

In 2010, Hohenwarter et al. highlighted often occurring barriers to the adoption of GeoGebra. Teachers in Florida's middle and high schools provided the information for the study. For the teachers, four GeoGebra sessions were planned, and surveys were used to gauge their opinions of the programme. They were tasked with rating the difficulty of each workshop's dynamic geometry tools and other software features. The difficulties of using GeoGebra and the levels of the dynamic geometry tools were determined by examining the responses. These served as the foundation for the creation of complexity requirements for dynamic geometry software tools.

Lavicza and Varga (2010) studied how GeoGebra can be used for Mathematics teaching in interactive whiteboard by arranging six workshops for Hungarian primary and secondary school teachers. The results revealed that

GeoGebra and IWB are useful for teaching Mathematics but together they are more powerful than using separately.

Review of Related Studies on Problem Solving Ability

The following are studies related to the variable Problem Solving Ability in general and in Geometry in particular.

Yunus and Rusdi (2021) carried studies the relationship between Achievement motivation, metacognitive awareness, and students' attitudes related to problem-solving abilities are less sensitive due to the limited effect of civic education in higher education in 148 students from universities in Indonesia. The results show that problem-solving abilities had a positive relationship with the following aspects: achievement motivation, metacognitive awareness, students' attitudes towards learning, and simultaneously, achievement motivation, metacognitive awareness and attitudes. This research confirms that teachers need to pay attention to achievement motivation, metacognitive awareness and attitudes of students related to learning strategies in improving the ability to solve problems.

Yunus and Setyosari (2021) conducted this study to find out the influence of online project collaborative learning and achievement motivation on problem-solving ability in the area of citizenship. This study uses a quasi-experimental design. The total of study subjects is 71 students of higher education; consist of 36 students as the experimental group and 35 students as the control group. Data of problem-solving ability is obtained by using an essay test, while data of achievement motivation is obtained by using a questionnaire. Data analysis is done with ANOVA (Analysis of Variance). The study results show that online based-project collaborative learning strategy has a positive influence on civic problem-solving ability. There is a difference in civic problem-solving ability between students with high achievement motivation and students with low achievement motivation.

Supiandi and Ege (2017) carried out this study to analyze the effect of Group Investigation (GI) model on the student problem solving ability and students' academic achievement on the digestive system material for students of grade 8 using quasi experimental design using rubric to test the effect of Group Investigation (GI) learning model on the student problem solving ability and students academic achievement. The results of the study showed that the Group Investigation (GI) learning model improved the student problem solving ability and students academic achievement. It is recommended that teachers implement Group Investigation (GI) learning model in schools consistently because it improves effectively on the student problem solving ability and students academic achievement.

Gok and Tolga (2015) examined the effects of strategic problem solving with peer instruction on college students' performance in physics. The students enrolled in 2 sections of a physics course were studied; 1 section was the treatment group and the other section was the comparison group. Students in the treatment group received peer instruction with systematic problem-solving strategies whereas students in the comparison group received only peer instruction. Data were collected on physics achievement, problem-solving strategies, homework problems, and students' opinions about the instruction. Results indicated that the treatment group students' homework and achievement test performances as well as their visualizing, solving, and checking habits improved relative to the comparison group students, which did not change noticeably. Treatment group students also changed their perspective on solving a problem and found the method helpful to connect the quantitative solution with concepts. These results revealed that the method could be implemented with little effort so as to assess and enhance student performance in science classrooms.

Laxmankumar (2010) in his study stated that information searching skills play an important role in Problem Solving. The findings affirm the need for students to be systematically instructed in the skills of information searching to be able to accomplish Problem Solving. Students have to be trained to apply a more advanced set of information searching skills in resolving ill-structured problems.

Some researchers have even linked home environment or conditions as related to Problem Solving. Researchers like Ahuja and Goyal (2005); Lakshmi and Arora (2006); Devi and Kiran (2002)

Kumari (1991) while studying on the Problem Solving strategies of children, revealed and recognized that there were sequential steps in Problem Solving and different forms or levels of responses to be associated with the tactics used by children. She also emphasized that the Problem Solving strategies of children and the success on different types of problems was significantly and positively related to each cognitive ability, separately as well as globally.

Thind (1990) has found, rather unexpectedly that rather socio-personal factors such as education of father and occupation of father or mother have no significant effect on the Problem Solving ability in mathematics of school children. However the education of the mother was found to have a significant effect on the Problem Solving ability of the children of classes VII-IX. Independent study, Punjab Agricultural University.

Krishnan (1990) has found that there is no significant relationship between identification of Problem Solving strategies (IPSS) and either application of Problem Solvingstrategies (APSS) or achievement of Problem Solving in mathematics (APSM), though the last two are significantly correlated. The essential problem in school mathematics is how to teach Problem Solving strategies to students so that they may become efficient problem solvers, M.Phil. in education Allagappa University

Krishnan (1990) in his study on high school students identified that the essential problem in school mathematics is how to teach Problem Solving strategies in students so that they may become efficient problem solvers.

High intelligent students, irrespective of strategies of training scored higher on Problem Solving ability than low intelligent students. Anxiety did not influence the Problem Solving ability of students. (Dutt, 1989). Dutt also asserted that in the interrelationship between Problem Solving ability and strategies, anxiety as a factor plays no significant role.

Lester (1982) postulated that successful Problem Solving in mathematics is a function of at least five components: (i) mathematical knowledge and experience, (ii) Skill in the use of a variety of generic "tool" skills (e.g., sorting relevant from irrelevant information, drawing diagrams, etc.). (iii) mathematical Problem Solving. (iv) knowledge about (one's own cognitions before, during, and after a Problem Solving episode, and) (v) the ability to maintain executive control (i.e. to monitor and regulate) of the procedures being employed during Problem Solving.

Nuzum (1983); Farooq (1980) have found out that children with low Home environment showed lower Problem Solving abilities and vice versa.

Like western researchers, Indian researchers also tried to find out the sex differences in Problem Solving ability. Kumar (1980) however, in his study failed to find out significant differences between the sexes.

While studying on the different methods of Problem Solving, Nipharake (1977) 6, Miyan (1982), Rais (1982), Reddy (1989) revealed findings that stated the usefulness of guided discovery methods and educational materials across different types of assessment tools and samples.

A few studies have however shown the superiority of females over males. Such includes those of Kumar (1974) and Singh (1979). While conducting studies among the sexes and Problem Solving, Bedell, (1934) and Billings (1934) by taking the school and college student, had projected their findings on the superiority of males over females in Problem Solving ability. However some studies failed to bring out this difference among the sexes. Such include those of Raaheim (1963) and Mendelsohn et al. (1966)

Milton (1957) explained the role of environmental factors on the problem of sex differences. This was done to find out the reason of poor performance of females in Problem Solving.

Several researches and experiments were conducted to determine the characteristics of Problem Solving among young and old adults. In this regard, while conducting studies on adults, Walford (1958) found out that older adults tend to make more enquiries about a problem while Jerome (1962) added that adults tend to repeatedly ask the same questions when given a Problem Solving tasks.

There has also been tremendous works done in the field of Problem Solving in science. According to Gagne (1965), cognitive science has resulted in a renewed focus on student's perception as integral to complex learning.

Problem Solving is determined by a host of cognitive functions. Stork et al., 1972, in their study of cognitive abilities among adults had revealed that Verbal Intelligence however is not closely related to Problem Solving.

In the same relation to Problem Solving among adults, Arenberg (1972) while doing a research on young and old adults emphasised on the result that adults find abstractions difficult and those with low IQ tend to show a decline in Problem Solving in early years.

Burger and Jacobson. (1979) studied to explore the association between sex roles and relationship adjustment and communication skills. Baucom's sex role inventory was administered to couples who also reported on their relationship satisfaction and engaged in Problem Solving exercises. Stepwise multiple regression analyses showed a significant positive relationship between femininity and satisfaction as well as between femininity and positive problem- solving behavior, and a significant negative relationship between femininity and aversive Problem Solving strategies. Additional tests revealed no significant relationship between androgyny and either relationship satisfaction or problem- solving strategies.

Once a problem is perceived, the mind must be engaged to construct a response. Larkin (1980) in his study on Problem Solving in Physics described this as what learners do after they have been given a problem.

Elliott (1999) examined in his study the relation of social problem- solving abilities to psychological and physical adjustment of persons with recent spinal cord injuries (SCIs) in a sample of 94 patients using correlation. The results revealed that greater negative problem orientation predicted each self-report outcome variable; completeness of lesion was the best predictor of pressure sore diagnosis. Conclusions: The problem orientation component appears to relate to self-reported adjustment among persons with SCI in a theoretically consistent fashion.

Robinson et al. (2000) studied about the Problem Solving abilities among mother of infants with failure to thrive. Behavliatrics and Psychology, Case Western

Reserve University, Ohio. The Maternal Problem Solving abilities, as they related to specific child-rearing situations, were examined and compared among mothers of infants with failure to thrive (FTT) and a matched group of comparison mothers. The study was conducted in 37 mothers of children diagnosed with FTT and 37 mothers with normally growing children matched on three child variables and five maternal variables. Multivariate analysis of covariance results supported our main study hypotheses that mothers of infants with FTT would generate fewer Problem Solving strategies that would be judged of poorer quality (i.e., less likely to result in positive outcomes) than mothers of healthy, normally growing infants. There were no significant associations obtained among Problem Solving variables and individual difference variables (e.g., depression, negative effect, and stressful life events).From the study, it can be concluded that limited maternal Problem Solving abilities may contribute to FTT by interfering directly with the quality of nurturance, feeling, and caloric intake the child receives. Recommendations are made for future research and interventions with mothers of children with FTT.

Meadows and Parries (1959) evaluated the creative Problem Solving courses developed by them in terms of gain in creativity. They found that the group receiving instruction through the experimental programme attained significant increments on the measures of quantity and quality of ideas. The results were interpreted to indicate that the creative problem-solving course produces significant increase on certain ability measures associated with practical creativity as well as on personality variable dominance.

In another evaluative study, the same investigators, Parnes and Meadows (1959) studied the effects of brainstorming on creative Problem Solving by trained and untrained subjects. 'Two problems designed to measure creative ability were given to both the groups. One problem was administered under deferred judgment instructions and the other under on current judgement. The result indicated that the subjects trained in a creative problem-solving course emphasizing deferred judgement principle produced a significantly greater number of ideas of good quality. The findings are intercepted to indicate that the deferred judgement instruction is an effective method of extending the incubation period and thereby increasing the production of ideas.

Anderson (1963) also studied the comparative effects of two methods of development o creative Problem Solving abilities in an industrial art course. The two treatments given were a series of nine brochures containing selected materials and short ideation exercise given to one experimental group and the brochures with nine oral imagination exercises to other group based on Osborn's brainstorming principles. The control group was taught through the traditional method. Pre and post test scores were obtained on the selected measures of Torrance tests of creative thinking and final test scores measuring attainment of course objectives were also obtained.

Shan et al. (1989) conducted a study on effectiveness of certain curricular activities in the development of creative thinking of high school students of the background hilly region of Jammu. The main objectives of this study were to study the effect of teaching through the curricular activities of brainstorming, Problem Solving, project activity and quiz in comparison to the traditional method of teaching, on the verbal fluency, flexibility, verbal originality and total verbal creative thinking of students. The study revealed that the groups of the students taught science using various curricular activities, namely, brainstorming, Problem Solving and quiz and project activity, gained significantly in verbal fluency, verbal flexibility, verbal originality, elaboration, non-verbal originality, total non-verbal originality, total non-verbal creative thinking and total creative thinking (verbal and non verbal) as compared to the groups taught by the traditional method of teaching.

Problem Solving , quiz and project activities were found to be equally effective, though significantly more so in comparison to the use of project activity in the development of total creative thinking among the high school students.

Sharma (1994) conducted an experimental study by organising activities like brainstorming, Problem Solving, quiz and project work in a science teaching class. She found that after the investigation, the students of the experimental group showed significant gains with respect to verbal fluency, verbal flexibility, verbal originality and non-verbal creative thinking.

Gutbezahl (1995) investigated “How Negative Expectancies and Attitudes Undermine Females' Confidence and Performance." According to this study, parents' and teachers' expectations for girls in academic achievements have an enormous impact on girls performance. Girls internalize their teachers' and parents' negative expectations, which become self-fulfilling prophecies. Because girls believe that they cannot achieve more through Problem Solving skills, they do not achieve more in academics. Their poor performance reinforces p & rents and teachers’ negative expectations and feeds the cycle of negative' expectations and lack of achievement. Clearly, teachers' and parents' expectations for girls' performance must be raised if girls are to have the opportunity to achieve more in academics.

Roberta and Julie (1999) investigated on “Changing Gifted Girls' Attitudes.” The objective of the study was to help gifted girls achieve even greater heights in academics. A study was initiated with academically gifted 4-7th grade girls that included activities, which 1) improved self-esteem, 2) developed positive attitudes, 3) dealt with problem-solving skills, 4) encouraged girls to become involved in Problem Solving skills and inquiry activities outside school, and 5) explored careers. In the study, it was found that the girls who had gone through it scored significantly higher on all subjects. The study helps girls deal with emotional and developmental issues as well ns improving their attitudes and performance in math. The study stresses that teachers can improve gifted girls' performance in by working with them on problem-solving skills and inquiry activities.

Alice and Sherryl (2004) investigated "Cognitive Therapy and Research". He found that Life stress is associated with depression, although it accounts for only about 10% of the variance. Social Problem Solving has been found to be a moderator of the stress-depression relationship in adults and children. This study extends research in this area by testing whether social Problem Solving moderates the relationship between stress and depression among adolescent girls and whether the moderating role of social Problem Solving is specific to certain domains of social Problem Solving. The hypothesized role of specific social problem-solving deficits in the association between stress and depressive symptomatology was supported. The study concludes that social Problem Solving - depression - stress - affect the divergent thinking among adolescence girls.

ValaBhagawanji (2005) had conducted a research on "Construction and try-out of Mathematical Problem Solving Programme (Verbal) for secondary school students". The study aimed to construct a mathematical Problem Solving programme for students of Std. 9 of secondary school, to find out the effect of Mathematical Problem Solving Programme on mathematical Problem Solving ability of secondary school students and to study in terms of achievement level the effect of the Problem Solving programme on mathematical Problem Solving ability of secondary school students. The main findings of the study was there was an extensive effect on mathematical Problem Solving ability. Due to the effect of the mathematical Problem Solving programme there was a significant increase in the Problem Solving ability of students. The students became aware of the basic ideas of the reasoning for various problems in maths. Beside, the ability to solve various problem had increased. This Mathematical Problem Solving Programme will generate self confidence among the students in solving various mathematical problems. The students will acquire the understanding about will method should be use for a certain problem.

Swarnalekha (1997) conducted a study on teaching through joyful activity of develop teacher empowerment, school effectiveness, strategies of teacher empowerment and mathematical Problem Solving ability at primary level through joyful teaching activity. The study found that there was a significant progress in teaching maths through Problem Solving Various skills like comprehension, decision making analysis, critical thinking, problem understanding, similar situations, etc. develop Problem Solving ability. Students show more positive attitude towards the teacher who spends more time to exchange communication and experiences. At the same time he teacher who does not provide an opportunity for communication, the students show negative attitude towards him/her. It is necessary to teach mathematics with full participation. To teach mathematics a teacher should enjoy mathematics, and develop teaching – learning activities so that the students love mathematics.

Sood (1999) conducted a study of mathematical achievement, creativity, Problem Solving ability and individual characteristics of students of residential and non-residential schools by the experimental method. The main findings of the research were: Mathematical achievement of students is related with their Problem Solving ability. The mathematical achievement of the students of residential school is related with fluency. There is a difference in fluency in residential and non-residential schools. Various stages of personality affect the mathematical achievement. The seven stages related with fluency are mental disorder, low mental ability, low creatively, influential personality, less influential personality, cleverness, conservativeness and theorist.

Jinfa (1995) studied on the mathematical performance of students of U.S. and China – a conceptual analysis of goal based calculation on simple Problem Solving and complex Problem Solving. The main findings of the study are that students can solve a problem in more than one way. 50% children in the U.S. believe that Mathematics is a subject to be remembered.

Students can easily solve simple problems while students take more time to solve complex problems.

Smith, Barbara Fowler (1988) conducted an investigation of the efficiency of a heuristic problem solving performance of eight grade mathematics students grouped by creativity and treatment level on 225 eight grade students grouped by creativity and treatment was the basis for this study in rurally based junior high schools. The study was a combined one and two-way quasi-experimental design with analysis of co-variance using intelligence as a co-variant. Findings of the study were that Problem Solving training was shown to produce improvement in mathematical Problem Solving performances in 8^{th} grade students without regard to creativity grouping. In 8^{th} grade students grouped high and low in creativity, students high in creativity scored higher in Problem Solving performance than students low in creativity even when intelligence was removed as a factor. Interaction of creativity and problem-solving training was not significant.

Lee (1989) compared the effects of programming and software application on mathematical problem-solving in secondary schools. The main objective of this study was to research the effects of the use of software tools and computer programming on mathematical Problem Solving in the secondary mathematics classroom. This study revealed that Computer treatment was not supportive for low level mathematics students. The computer treatment was supportive for medium level mathematics students and for the high level mathematics students no treatment was needed in problem-solving.

Molefe (2004) investigated the effect and role that culturally relevant Problem Solving in the language of their choice may have on learning mathematics. The study revealed that, majority of the participants, preferred to communicate their mathematics thoughts in a mixture of English and their first language. They solved problems they could not solve before using own strategies. These strategies differed from person to person andCulture had an influence on the type of strategy to be used and the solution of the problem.

Ayodhya (2007) attempted to blend problem-solving skills to learner's achievement and conducted a study to know the impact of Problem Solving instruction through Polya's heuristic approach on the achievement of mathematics and to know the correlation between the problem-solving skills of the students and their achievement. This study revealed that there is significant improvement in the problem-solving skills of the students who were exposed to Polya's four-step process to solve problem. There is significant improvement in the scholastic achievement in mathematics in the majority of the schools that were exposed to the Polya's method. The improvement in the problem-solving skills of the learner might contribute to the improvement in their scholastic achievement in mathematics and there is a substantial correlation between Problem Solving skills and achievement of the students in mathematics.

Naglaxmi (1996) conducted a study on construction of mathematical Problem Solving test for secondary school students and the Problem Solving ability of student of Std. 10 of Hyderabad by the experimental research method. The objectives of the study was to measure the mathematical Problem Solving ability of boys and girls and to measure the mathematical Problem Solving ability of students of rural and urban areas. The study revealed that boys are good in measuring numerical reasoning whereas girls are good in measuring verbal reasoning. The student of rural areas have shown better performance that the students of urban areas. Socio-economic status (SES) in an improving factor in the mathematical Problem Solving ability.

John and Ramganesh (2009), conducted a study on, 'Creative Problem Solving Ability of XI standard students'. The objectives of the study were to identify the level of creative problem – solving ability of XI standard students and to find out, if any, the significant differences in creative Problem Solving ability in terms of background variables namely, sex, type of school, type of syllabus and locality. The finding showed that students who completed their high school under matriculation syllabus were more creative than the students who completed their high school under the syllabus prescribed by the government of Tamil Nadu.

Behera, (2009), conducted a study on 'Problem Solving Skills in Mathematics Learning' to study the cognitive skills of students with high mathematical ability and low mathematical ability on Mathematics Problem Solving and to ascertain the gender difference in Mathematics Problem Solving skill. The mean difference between high ability and low ability groups, between boys and girls within each ability group was quite large. The summary of ANOVA revealed significant effects on Problem Solving ability and the main effects of Problem Solving ability were highly significant.

Zakaria and Yusoff (2009) conducted a study on, 'Attitudes and Problem - Solving Skills in Algebra among Malaysian Matriculation College Students'. The findings showed that Matriculation students had moderately favorable attitudes towards algebra Problem Solving and no significant difference in attitudes and Problem Solving skills based on gender were observed. However, significant difference in attitudes – specifically, with regard to self confidence and Problem Solving skills between students in different courses of study exists.

Ching-ChihKuo et al. (2010), conducted a study on 'Identifying Young Gifted children and Cultivating Problem Solving Abilities and Multiple Intelligences'. The results of this enrichment program showed that most students performed well on five kinds of Problem Solving types. It is worth noting that participating children presented scientific thinking characteristics, such as rich knowledge with fascinating imagination and the ability to seek many approaches to solve problems. Children were delighted to challenge others and pleased to be challenged. The exceptional children also performed well in the program, especially those children with autism whose progress in social skills and group adaptability were remarkable.

Brad (2011) conducted a study of the Problem solving Activity in High School Students: Strategies and Self-Regulated Learning with the purpose of analyzing high school students' approach to Problem solving activities, namely the meta cognitive abilities and the strategies they employ. The results show that although students apply basic strategies well, they use a trial-and-error approach, they give-up when faced with difficulties and have deficiencies in metacognitive abilities, which are indications that must be taken into account. The study calls on the need for greater attention be given to the students' needs, putting more emphasis on reasoning and understanding, so that students can improve their self-regulated learning.

Rudmann, (2002) studied on Solving problems in a visuospatial domain, such as astronomy, suggests that it may require not only knowledge about the phenomena within the domain but an ability to instantiated knowledge spatially to generate solutions, as well. Spatial ability assessments and interviews of undergraduates show that problem solving ability can be limited regardless of the scientific accuracy of an individual's causal beliefs about astronomy. Spatial ability was found to be somewhat positively correlated with Problem solving performance, regardless of the causal beliefs an individual holds. Providing external aides coloured balls for help with spatial reasoning improves performance, a further sign of the influence of spatial ability on Problem solving. The specific causal explanation for a phenomenon an individual believes may itself be related to spatial ability. For learners to better understand and apply scientific explanations of astronomy, it may be necessary to provide spatial skills training as a component in instruction.

Lamm et al. studied The Influence of Cognitive Diversity on Group Problem solving Strategy. (2012) Collaborative group Problem solving allows students to wrestle with different interpretations and solutions brought forth by group members, enhancing both critical thinking and Problem solving skills. Since Problem solving in groups is a common practice in agricultural education, instructors are often put in the position of organizing student groups and facilitating group learning. Research has shown that the factors according to which teachers arrange groups hold great influence over the success experienced by a group. The purpose of this study was to examine how arranging groups by Problem solving style influenced group Problem solving processes. Groups made up of members with heterogeneous or homogenous Problem solving styles were given a problem to solve as a class project. Focus groups were conducted with each group at the conclusion of the project to gain an understanding of how each group progressed through the Problem solving process. Differences were found in how homogenous versus heterogeneous groups progressed through the Problem solving process. With a greater understanding of how Problem solving style influences group dynamics, agricultural educators can be more proactive when assigning student work groups, thereby enhancing students‟ abilities to work interdependently when creating successful solutions. F. Westbrook - the effects of differentiating instruction by learning styles on Problem solving in cooperative groups (2011). It can be difficult to find adequate strategies when teaching Problem solving in a standard based mathematics classroom. The purpose of this study was to improve students‟ Problem solving skills and attitudes through differentiated instruction when working on lengthy performance tasks in cooperative groups. This action research studied for 15 days whether students in a treatment group (n = 28), who were grouped by learning styles (auditory, kinesthetic, and visual), would display greater ability learning the standards or display better attitudes towards Problem solving when compared to a control group (n = 28) who were grouped in random cooperative groups. When the qualitative and quantitative data were analyzed, the results demonstrated that the treatment group did not show significant gains when compared to random cooperative groups.

Süleyman - determination of the Problem solving level of gifted/talented students. (2012) It is important to determine and develop Problem solving skills of gifted and talented children, who have different emotional characteristics compared to peers, in terms of using their potentials at the highest level. In this research, which was done with the aim of determining self-sensations of gifted and talented children in Problem solving skills, it was examined if gender and grade level variables create differences on sensations for Problem solving skills of gifted and talented children. The study group of research that was done by using Survey method is made up of

100 students who attended Sivas Science and Art Centre in spring term of 2010-2011 Education year. As a data collecting tool in study, “Problem solving Inventory for Children” that was developed for primary school students by Serin et al. (2010) was used. Inventory (ÇPÇE), its Cronbach alpha reliability coefficient is 0.80, is made up of three factors, “Confidence”, “Self-control” and “Avoidance” and 24 items in total. Collected data was analyzed by using SPSS 12.00 programme. In this context, “t”, “F”, “schefee”tests and “correlation analysis” were applied. As a result of study, according to the findings, it wasn‟t found any significant differences between total point of gender, grade levels, Problem solving skill sensation and point averages of subscales. Keywords: Problem solving, gifted/talented students

Zanzali -Evaluating the levels of Problem solving abilities in mathematics (2008). Currently, there is a general agreement among mathematics educators that students need to acquire Problem solving skill, learn to communicate using mathematical knowledge and skills, and develop mathematical thinking and reasoning, to see the interconnectedness between mathematics and other disciplines. Based on this perspective, this research looked into the levels of Problem solving ability amongst selected Malaysian secondary school students. A sample of 242 form four science and non science students from four schools in an urban district participated in this research. There respondents were asked to solve several mathematical problems. The student’s level of abilities in using basic knowledge, standard procedure and Problem solving skills were evaluated from their written response. The evaluation was done based on polya’s Problem solving model. Data were gathered through questionnaire and interviews. These data indicated that students have limited exposure to Problem solving instruction. Research findings also showed that students have fairly good command of basic knowledge and skills, but did not show the use of Problem solving skills. Most of the students were unable to use correct and suitable mathematical symbols and vocabulary in providing reasons and explanations for certain Problem solving procedures. It is hope that these findings will serve as a reference for educators in improving the learning and teaching of mathematics in general and Problem solving instruction in particular.

Adeyemo (2010) conducted a study on Student's ability level and their competence in Problem solving task in physics. This study was carried out on student's ability level and their competence in Problem solving task in physics. The study used for the study was selected randomly from four secondary school in Kosofe local government area of Lagos state. A total of two hundred (200) randomly selected SSS physics students in Kosofe local government area served as the subject for the study. Three null hypotheses were postulated and tested at 0.05 level of significance to find student's ability level and their competence in problem-solving task in physics. The instrument used for the study was student's questionnaire and student's achievement test. The data collected were analysed using simple regression analysis. The results of the findings showed that students ability have significant influence on problem-solving task are discussed.

Some studies conducted in relation to geometry teaching are discussed as follows:

Manchisi (2021) studied the Euclidean geometry learning experiences of 16 Grade 11 students from four South African secondary schools. Students who taught using a Van Hiele theory-based approach reported positive learning experiences in Euclidean geometry, while those engaged in conventional learning reported negative learning experiences. Van Hiele theory-based approach seems to be more effective than conventional approaches in learning Euclidean geometry.

Arvanitaki and Zaranis (2020) investigated students' achievement in geometry regarding solids' nets using ICT integrated teaching among primary school students of fourth grade. The results of the study indicated that teaching and learning through ICT has a positive outcome for students at primary school and as compared to the traditional teaching method.

Weckbacher and Okamoto (2018) explored how cognitive abilities and cognitive style might be related to geometry. High school students studying geometry participated in the study. The results showed that the two spatial measures were significantly correlated to geometry performance and not cognitive style.

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.

Haralambos (2000) examined how students conceptualize various geometric concepts in tenth-grade geometry. It provided the suggestion of additional strategies for the improvement of the teaching and learning of geometric proofs. Further results of the research indicated that students write proofs that are better organized through shared knowledge than the proofs presented in the textbooks.

Dutta (1990) discussed diagnosis and prevention of learning disabilities in the reasoning powers of the students in geometry. The study consisted of preventive measures adopted by experimenter with the help of audio-visual methods and techniques. The sample comprised of 148 students covering both the genders and belonging to both rural and urban areas. Using an experimental design, the study was conducted using a diagnostic test, an attainment test and a teaching strategy. The collected data were treated with ANOVA. Major findings were: The experimental taught by audio-visual materials and techniques achieved significantly more than the control group taught by conventional method. The experimental group showed more prolonged retention and interest in the lesson than the control group. It was also found that the preventive measures had a positive impact on the group and showed more interest in the lesson.

Premlatha (2002) The purpose of this study was to investigate the complex cognitive process involved in learning non-Euclidean geometry and understanding geometry as an integrated whole, taking into account both the psychological and social aspects of learning. To this end, a qualitative study was conducted to answer two research questions: (a) How does students' understanding of straight lines and triangle develop in spherical geometry? and (b) How does prior knowledge of Euclidean geometry impact development of non-Euclidean geometry? Understanding of spherical geometry developed along the following paths: the individual's experience outside of mathematics the socio-mathematical norms of the class that encouraged students to create their own meaning of concepts and conflict resolution with prior knowledge of Euclidean geometry. Conflict was resolved by motion, analogy, mental rotation, formulating definitions and taking an intrinsic view. Prior knowledge of Euclidean geometry impacted development of non-Euclidean concepts. Students had difficulty viewing the sphere as a world in its own right: they tried to maintain their Euclidean images,-transformations and definitions. -

Gurusamy (1990) attempted to diagnose the errors committed by students of class IX in solving problems in geometry, and has developed a remedial package. The case study method was used to observe the causes of committing errors by the students in solving geometry problem, questionnaire developed by the investigator was sent to 20 expert geometry teachers of standard IX. Percentages were computed for comparison and interpretation of errors. The collected data were treated with mean, standard deviation and 't' test. The remedial package was designed and implemented to the students. It was claimed that the remedial package leads to considerable reduction in errors in geometry by the students and the level of performance of the students was high.

Sarala (1990) surveyed the conceptual errors of secondary school pupils in learning selected areas in mathematics. The sample comprised of eight hundred pupils from secondary schools in Trivandrum revenue district. The tools used were diagnostic tests in sets, trigonometry and in statistics, the Non-verbal test of Intelligence by Nafde, personal data sheet. The major findings were that the number of conceptual errors committed by secondary school pupils in the areas selected for the study was very high, Conceptual errors in mathematics were seen to be influenced by sex, locality of school, management of school, intelligence, study habits, socio-economic status and caste.

Jaguthsing (2003) found that in addition to the synthetic approach, algebraic approaches are inherent in the use of transformations, coordinates, and vectors to study geometry. This study investigated secondary students' use of algebraic thinking: the use of symbols and algebraic relations, the use of different forms of representations, and the use of patterns and generalizations in geometry and their related conceptual difficulties. The results show that the students used algebraic thinking in solving problems in geometry, but they had several difficulties as well, including: understanding the nature of a variable, writing an equation/expression, recalling and using formulae, understanding the use of different forms of representations, finding generalizations from patterns. Sometimes a geometrical concept/idea was the source of their error and sometimes it was an algebraic concept. In addition, it was found that students' use of algebraic thinking was related to their teacher's use of the same in their classes.

Samuel (1989) investigated the thinking and reaction of seven to ten year old children when they face practical problems concerning the fundamental concepts of weight, area and volume as explained by Jean Piaget. One thousand and forty - seven children of the age -group 7 years 5 months to 9 years 11 months and 40 children from class 2nd and 3rd from 9 schools in Bangalore city were included in the sample. The tools used were Raven's coloured Progressive Matrices sets, and test material designed by Joseph Rogers. The statistical techniques used were percentages and chi-square. He found that in Piaget's main thesis the conceptual process followed stages of development. The Piagetian stages of development from perceptual reasoning to concreto-logical reasoning were also confirmed. He has also found that there was a relationship between the mental ability of the children and their ability to understand the concepts of conservation of area, mass and volume Dutta (1990) discussed diagnosis and prevention of learning disabilities in the reasoning power of students in Geometry. He reported that the disabilities were there because the teaching of Geometry was geared to the needs of the most able students, there were no experiments to strengthen the teaching of Geometry, and the relation of Geometry and physical space was not explored. He further remarked that the use of audio-visual material leads to greater interest, clearer understanding and longer retention of geometrical concepts.

Yadav (1990) explored whether the home culture of the children in the form of their socio-economic status has a significant impact not only in their schooling but also in their learning process in the classroom. Six hundred and three pupils were selected, adopting a systematic random technique. The tools used in the study were socio-economic status scale by Kuppuswami and Piaget-type tasks with some modifications, adopted in Hindi, to study the geometrical-concepts formation. A 5x3x2 factorial design for elementary school level and a 3x3x2 factorial design for the middle school level were used for analyzing the data. The major findings were: !) All the three factors namely age, SES and school environment, had a significant effect upon concept formation in Geometry. 2) Interaction effects significantly affected the concept formation in Geometry at both the levels

Ubuz (1999) examined tenth and eleventh grade students' understanding of basic Geometry concepts and showed that students did not know the meaning of a triangle and the properties of exterior and interior angles of a triangle. They thought that trapezoid as a parallelogram without thinking its properties. Another finding related with polygons was that students applied the properties of regular Polygons to any non-regular pentagon. She further investigated tenth and eleventh graders understanding of angles according to their errors, misconceptions and gender. She found that students had misconceptions on special angles constructed between a pair of parallel lines cut by a transversal. She suggested that the reasons of students' difficulties can be summarized as follows: students assumed something was given by looking at the figures, they focused on the figure itself rather than its properties, and they did not know the meaning of exterior and interior angles of a triangle.

Rath and Panigrahi (2003) identified the indicators for quality teaching of fundamental concepts of Geometry in class iv. The sample included 50 students of a primary school. Some of the findings of the investigator were as under: l. The strategies enhanced student participation, 2. The indicators used for quality teaching were superior to formal technique of teaching, 3. As student participation was more and /better the strategies proved effective, 4. Better participation and enhanced attention resulted in better academic performance in achievement tests.

Duatepe (2005) investigate the effects of drama-based instruction on seventh grade students' achievement on Geometry (angles and polygons; circle and cylinder), retention of achievement, van Hiele geometric thinking level, attitudes toward mathematics and attitudes toward Geometry compared to the traditional teaching. The quantitative analyses were carried out by using two multivariate covariance analyses and the results revealed that drama-based instruction had a significant effect on students' angles and polygons achievement, circle and cylinder achievement, retention of these achievement, van Hiele geometric thinking level, mathematics attitude, and Geometry attitude compared to the traditional teaching. The study highlights the potential of the drama-based instruction to make learning more comprehensible by creating collaborative studying environment, giving chance to improvise daily life examples, giving opportunity to communicate, providing meaningful learning, supporting long-lasting learning and providing self-awareness.

Yazdani (2007) conducted an experimental study to explore the existence of a relationship between the van Hides' level of understanding Geometry and achievement in plane Geometry in a sample of 169 students. A correlation coefficient of .8665 in the post test on students' level of understanding Geometry according to the van Hides' Model and students' achievement in Geometry indicated a strong positive correlation between the advancement of the van Hides' level of understanding Geometry and achievement in Geometry.

Siyepu (2005) conducted explored the effectiveness of van Hiele theory to solving problems faced by grade 11 learners in the topic circle in Geometry. The study revealed that many of the grade 11 learners were under-prepared for the study of more sophisticated Geometry concepts and proofs and also supported the finding that the van Hiele levels of thinking are hierarchical.

Halat (2006) examined the acquisition of the van Hiele levels and motivation of sixth-grade students engaged in instruction using van Hiele theory-based mathematics curricula in 150 sixth-grade students. The study demonstrated that gender was not a factor in learning Geometry. The results showed that none of the sixth-grade students in the study progressed beyond level-II of the analysis which reflects their motivational level.

Mateya (2008) analyzed the geometrical conceptualization in Grade 12 mathematics students on van Hiele theory of geometric thinking in Namibia 50 students of grade 12. The results indicated that majority of students have a weak conceptual understanding of geometric concepts were at van Hiele level 3. These results are found to be consistent with those of previous similar studies conducted across UK, USA, Nigeria and South Africa.

Henderson (1988) investigated the pre-service teachers' geometric knowledge based on the van Hielemodel using Mayberry's interview-based instrument video recording of the classes of high school Geometry students. Stimulated-recall interviews during and following the teaching segment for each pre service teacher was also conducted. The study reveals that pre service teachers' geometric thinking levels were reflected in their instruction which indicates that the level of understanding of pre service teachers influenced students' difficulty or insight.

Halat and Peker (2008) investigated the impact of teaching experience on the van Hiele levels of in-service elementary school teachers in Geometry in 120 in-service elementary school teachers. The study found that teaching experience appeared to be a vital factor affecting the in-service elementary school teachers' van Hiele levels. Teachers who had 1-4 years of teaching experience showed higher geometric reasoning stages than the ones who had 5-10 years or 11-up years of teaching experience. The results also indicated that the in-service elementary school teachers showed all van Hiele thinking levels except level-V (Rigor) in different percentiles.

Jacobson and Lehrer (2000) conducted professional development for four elementary teachers on student understanding of arithmetic; two of the teachers also attended seminars addressing children's ideas of Geometry and space. The study reported that in cases where teachers were more knowledgeable about students' thinking about space and Geometry students learnt more than their counterparts. Also this supports that teachers should be abreast of learning theories like the VH model.

Bayram (2004) investigated the effects of concrete models on eighth grade students' Geometry achievement and attitudes toward Geometry on 106 eighth grade students in a private school at Ankara. Students were engaged with received instruction both with concrete models, and by the traditional method. The results of the study indicated that there was a statistically significant mean difference between students received instruction with concrete models and those received instruction with traditional method.

Shrestha (2005) studied the effectiveness of Van Hide's Model of thinking at theoretical level for secondary school Geometry in Nepal. The sample consisted of ninth grade secondary school students of Katmandu Valley in Nepal. Multistage sampling /technique was adopted to select 270 students from seven sections in five schools. Treatment was based on the Van Hide's Model of thinking in Geometry at theoretical level . Some of his findings were as follows l. Treatment group students were higher on VHP performance than control group students. 2. Private school students were higher on VHP performance than Govt. school, 5) Van Hide levels made contribution on proof performance.

Ding and Jones (2007) conducted a study aimed at explaining how successful teachers teach proof in Geometry. Through a careful analysis of a series of lessons taught in Grade 8 in Shanghai, China, the study reported on the appropriateness of the van Hiele model of 'teaching phases' within the Chinese context. For the purposes of this study, data, collected in 2006, was selected from the teaching of one teacher, referred to as Lily (pseudonym), in an ordinary public school in a typical suburb of the city. The teacher, selected because of very good reputation for student success, had over 20 years teaching experience of secondary school mathematics. At the time of the data collection, there were 39 students in the class and mathematics lessons, each 40 minutes long, took place six times each week. Every lesson with this teacher was observed over a three week period. During this time, 12 Geometry lessons were observed with topics concerning parallelograms, rectangles, rhombi and squares. In total, four definitions and fifteen theorems were taught during the three-week observation period. Given the known expertise of the teacher, supporting evidence showed that the students were ready for this level of mathematics. The data collected included classroom observations notes, audio- recordings of lessons (transcribed), and other field notes. During each lesson, photographs were taken to provide information which could not be recorded by audio-recorder or field notes (for example, recording work presented on the blackboard). The analysis presented in this study indicated that the van Hiele theory can be a way of characterizing the teaching phases in geometrical proof. The analysis indicated that though the second and third van Hiele teaching phases could be identified in the Chinese lessons, the instructional complexity of, for example, the guided orientation phase means that more research is needed into the validity of the van Hiele model of teaching

Idris (2009) conducted a quasi-experimental study on the impact of using Geometers' Sketchpad on Malaysian Students' achievement and Van Hiele Geometric Thinking. 65 secondary school students of Malaysia participated in the study with 32 students of the treatment group undergoing the lessons using the Geometers' Sketchpad for ten weeks and the remaining 33 students in the control group taught by a traditional approach. The students' van Hiele levels of geometric thinking were assessed by van HieleGeometry Test (VHGT). Different instructional materials were used for the experimental and control groups. The results of the study showed positive effects of Geometer's Sketchpad and the van Hiele model to mathematics teachers and educators. The results showed significant differences in Geometry achievement of the experimental groups as compared to the control groups which indicate that the geometer's sketchpad shows promising implications for the potential of using the Geometers' Sketchpad in teaching Geometry at the secondary school level.

The study of Atebe (2008) was inspired by and utilised the van Hiele theory of geometric thought levels. The study aimed both to explore and explicate the van Hiele levels of geometric thinking of a selected group of grades 10, 11 and 12 learners in Nigerian and South African schools. The study provided an in-depth description of the geometry instructional practices that possibly contributed to the levels of geometric conceptualization exhibited by the high school learners. The case study applied both qualitative and quantitative methods. The sample consisted of 144 students and mathematics teachers from Nigeria and South Africa selected by both purposive and stratified sampling techniques. Data was acquired by administering questionnaires (consisting of pen-and-paper tests and hands-on activity-based tests), interviews and classroom videos. The data analysis was accomplished through descriptive and inferential statistics. Subsequently, participants were assigned to various van Hiele levels according to Usiskin's (1982) forced van Hiele level determination scheme. The classroom videos were analysed by a consultative panel of 4 observers and 3 critical readers, using a checklist of van Hiele phase descriptors to guide the analysis process.

The results from this study reveal that most of the learners were not yet ready for the formal deductive study of school geometry, as only 2% and 3% of them were respectively at van Hiele levels 3 and 4, while 47%, 22% and 24% were at levels 0, 1 and 2, respectively. No learner was found to be at van Hiele level 4. Further, the study found that the South African students performed better than the Nigerian students as per the Van Heile levels. Also, the results showed that boys performed better than the girls.

Conclusion

Above review of studies on virtual learning environment and on Geometry learning and implementation of virtual atmosphere such as GeoGebra reveal that the factor critical to successful implementation of VLEs is student acceptance of the system. A long tradition of research on technology acceptance has established that the (potential) user's perceived ease of use and perceived usefulness are central factors in explaining the acceptance and use of new technologies. Technology acceptance studies in contexts other than e-learning point out that perceived ease of use and perceived usefulness are influenced by individual differences and by external factors such as system characteristics, the availability of support, and the social context in which the technology adoption should take place.

The subject of mathematics is most often considered a core and complex subjects at all levels of schooling. Efforts to tackle this, at the same time implementing psychologically acceptable technological innovations to teaching learning mathematics for developing both lower order thinking skills and higher order thinking skills is the need of the hour.

Since the current era demands individuals with skills, acquisition of skills or transfer of skills is the need of the hour rather than acquisition of mere knowledge. From reviews, the investigator could realize that, as a core higher order skill Problem Solving Ability is a must have skill to excel in any profession as well as in real life.

The subject of discipline which require Problem Solving Ability to learn and the subject which empower Problem Solving Ability is Mathematics. The major branch of Mathematics Geometry, contributes much in development of Problem Solving Ability in learners. Unfortunately even though the present curriculum in Kerala sate boasts about it's constructivist approach in teaching learning, it is not sufficient by itself to foster Problem Solving Approach. So it is high time to adopt approaches that promote higher order cognitive skills in teaching learning process. In this context, the reviews compels the investigator to carry out his research on Problem Solving Ability.

Chapter **3**

METHODOLOGY

- *Method adopted for the study*
- *Phases of the study*
- *Design of the study*
- *Variables of the study*
- *Objectives of the study*
- *Hypotheses of the study*
- *Samples selected for the study*
- *Tools used for data collection*
- *Experimentation Procedures*
- *Scoring Procedures*
- *Statistical techniques used*

METHODOLOGY

Research refers to the activity of collecting, processing and interpreting data in an orderly and systematic manner. Methodology enables the researcher to look at the research problem in a meaningful and orderly way. Methodology is the technique or procedure adopted in a research study or investigation. It can be understood as a science of studying how research is done scientifically.

The present study is entitled as "**Effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students"**. This study attempts to find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry among Secondary School students.

The design of the study is described under the following sections.

- Method adopted for the study
- Phases of the study
- Design of the study
- Variables of the study
- Objectives of the study
- Hypotheses of the study
- Samples selected for the study
- Tools used for data collection
- Experimentation Procedures
- Scoring Procedures
- Statistical techniques used.

Method Adopted for the Study

Methods mean the range of approaches used in educational research to gather data which are to be used as a basis for inference and interpretation (Cohen et al. 2000). The accuracy of the result of educational research or any research depends upon the methods through which the conclusions are arrived at. Research methods are of at most importance in research process. Research methods and techniques are useful for the classification and organization of unorganized mass of data. Methods refer to the techniques and procedures used in the process of data gathering. They are the ways in which data are collected, classified, hypotheses formed and tested and the laws formulated.

The present study intends to find the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School students. The Investigator developed a Virtual learning Environment on Geometry with Geogebra as a major element and then studied its effect on Problem Solving Ability in Geometry of Secondary School students.

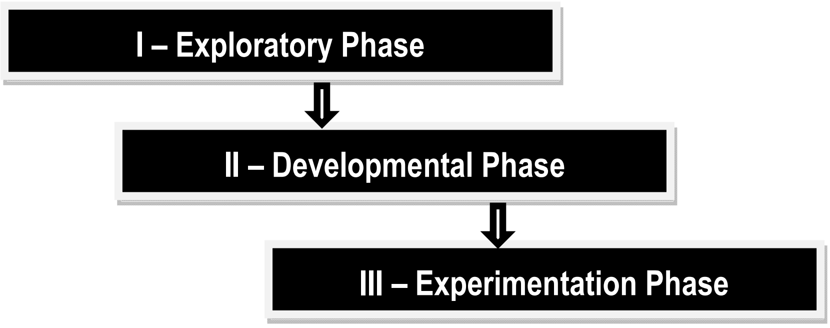
For the conduct of the study Experimental method was adopted. To compare the effect of Virtual Learning Environment, two groups were set up; viz. Experimental group and Control group. Experimental group was treated with the Virtual Learning Environment using Geogebra and the Control group was taught with the Conventional. Instructional strategy currently used in the schools in Kerala state following SCERT curriculum.

Phases of the Study

The study progress through three phases viz, Exploratory phase, Developmental phase and Experimental phase as represented in figure 11 below,

Figure 11

Graphical Representation of the Phases of the Study



A brief description of each phase has been given below:

Exploratory Phase

In this phase the investigator explored various aspects concerning the research to have a strong base for the conduct of the research. The investigator gone through many studies of similar nature. Studies conducted on Problem solving ability, Virtual Learning Environments and Geogebra are explored for thorough analysis. This helped the investigator to know the nature of the studies carried out and fix scope and limitation for the present study.

Here, the investigator examined various Virtual Learning Environments for its appropriateness, hurdles in development, technical and financial feasibilities, applicability in the present situation, effectiveness etc,. Exploration of various Virtual Learning Environments, helped the investigator to identify and develop the best suitable Instructional strategy.

Discussion and interactions with experts and teachers of mathematics in high schools narrowed the selection of topics in geometry for intervention and helped in identifying the major application and multimedia elements to be incorporated in the proposed Virtual Learning Environment.

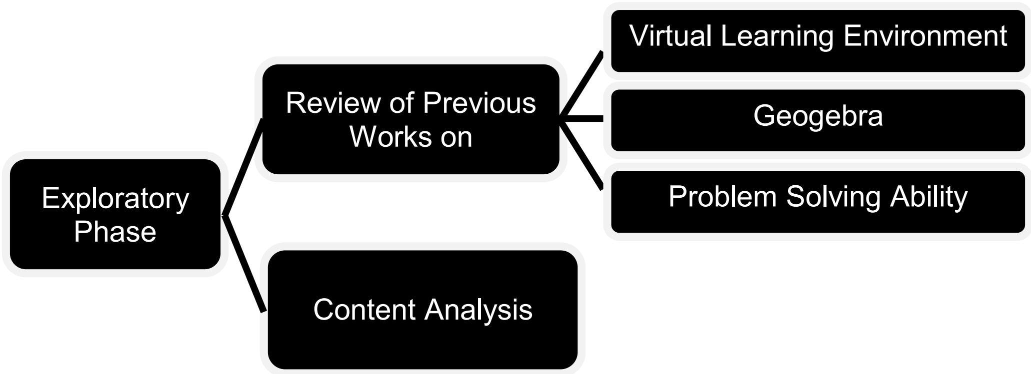
The chapter 'Prisms' in geometry of 9th standard Mathematics text book as per SCERT curriculum prevailing in Kerala state has been chosen for the intervention. Content analysis of the same was done in detail. Also it has been decided to use Geogebra as the major element of the Virtual Learning Environment.

Reviews, studies and discussions imparted a strong insight to the development of a Problem Solving Ability Test and for the identification of a Nonverbal Intelligent Test.

A graphical representation of the exploratory phase is given in the figure below,

Figure 12

Graphical Representation of the Exploratory Phase



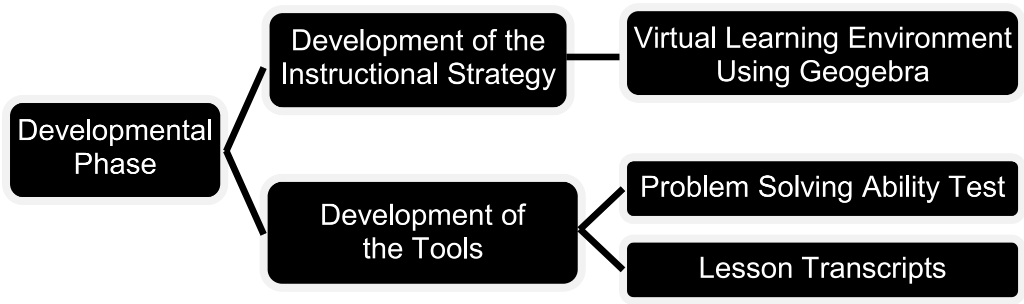
II. Developmental Phase

In this phase, based on the discussions and studies conducted in the first phase all the tools and instructional strategies are developed. At the outset, content development has been done so as to design the modules of Virtual Learning Environment. Considering the content analysis and sequencing of the content area, six modules have been identified. Each module contained introduction, illustration, and evaluation elements. Lesson transcripts and preparation of scripts for each module done with due care. Geogebra applets and other multimedia components like animations, videos and images were prepared in the format so as to integrate in the Virtual Learning Environment platform. Finally, Virtual Learning Environment using Geogebra as the major element has become a reality. The same has been placed for expert opinion and necessary modifications made wherever necessary.

Lesson transcripts for teaching the content to the control group and tool for assessing the Problem solving Ability were also prepared in this phase. Activities carried out in this phase has been depicted in the figure given below.

Figure 13

Graphical Representation of the Developmental Phase

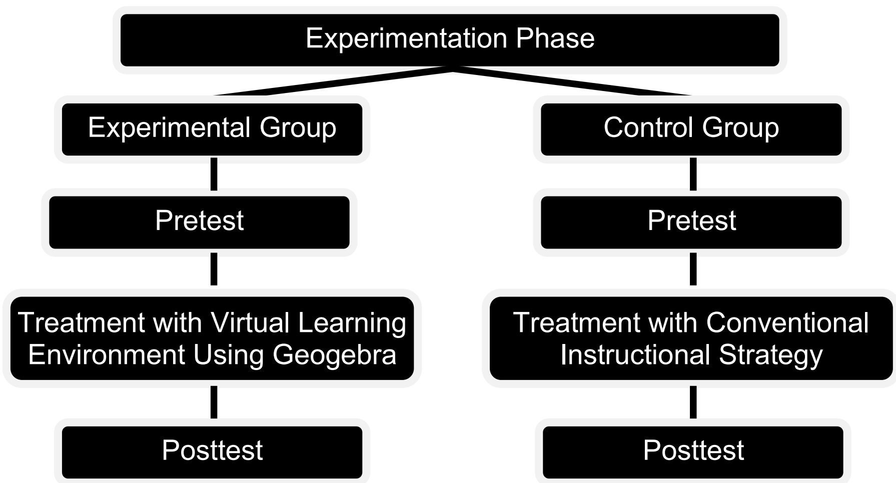


Phase III. Experimentation Phase

At this stage, the experimentation began by administering pretest on both experimental and control groups. A Nonverbal intelligence test was also administered on both group in this stage. Then the experimental group is treated with Virtual Learning Environment using Geogebra and the control group with Conventional Instructional Strategy. After the treatment both the control group and experimental group were administered with posttest. Various activities of the experimentation phase are illustrated in the figure 14.

Figure 14

Graphical Representation of the Experimentation Phase



Design of the Study

Research design is an outline or a plan to be set by the investigator on how to carry out the research. According to MacMillan and Schumacher 1984, Research design refers to the plan and structure of the investigation used to find out evidence to answer research questions.

As mentioned, Experimental Design is selected by the investigator for the present study. Experimental design is the blueprint of the procedure that enables the researcher to test the hypotheses by reaching valid conclusions about the relationship between independent and dependent variables (Best & Khan, 2010).

The experimental design selected for the study was quasi experimental pre-test post-test nonequivalent design. Design of the study can be symbolically represented as below

Experimental group → O_1 X O_2

Control group → O_3 C O_4

Where,

O_1 & O_3 are Pre-Tests

O_2& O_4 are Post-Tests

X – Exposure to Experimental Treatment

C – Exposure to Control Treatment

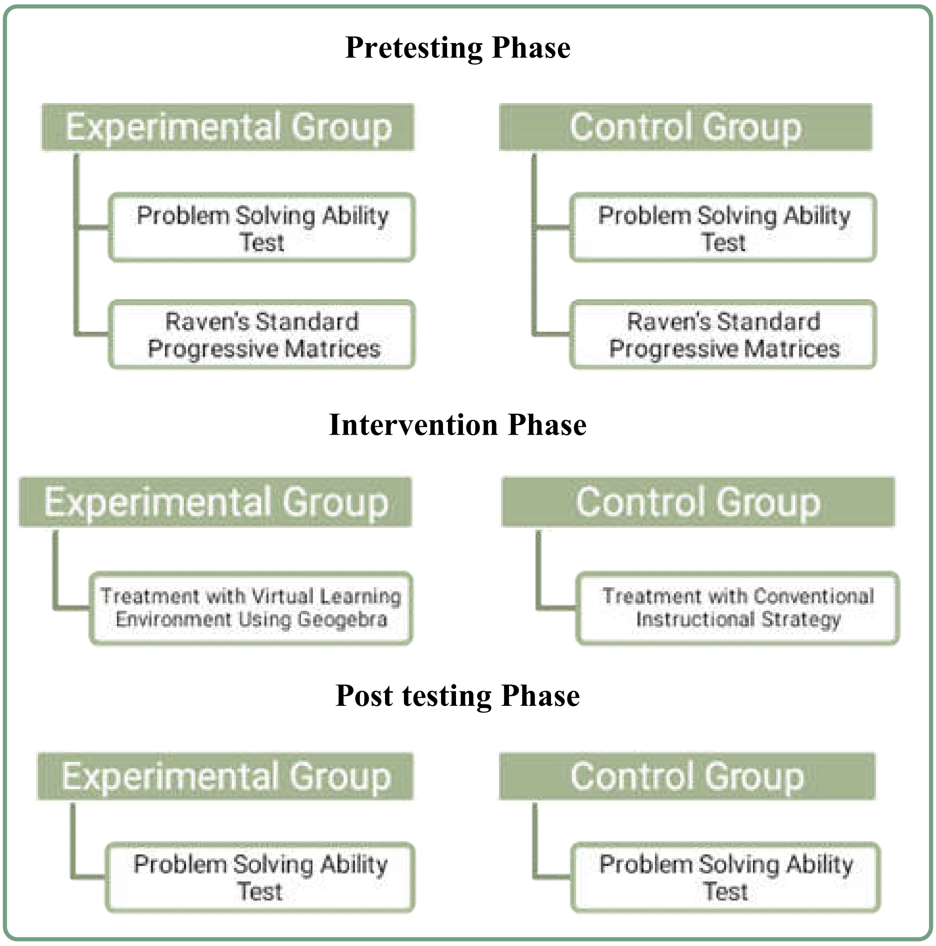
For the present study two intact classes of IX standard students of Al-Anvar School in Malappuram district of Kerala has been selected. One group was selected as experimental and the other as control group. At the beginning of the experimentation Pretest on Problem Solving Ability in Geometry has been administered on both experimental and control groups. To test the Nonverbal Intelligence of subjects, the investigator administered Standard Progressive Matrices Test prepared by JC Raven.

Afterwards, Experimental group has been treated with Virtual Learning Environment with Geogebra for learning Geometry prescribed in the curriculum. For the control group, conventional method of teaching has been carried out to teach geometry in the prescribed curriculum of standard IX.

After completion of the experimentation with Virtual Learning Environment using Geogebra in geometry in experimental group and conventional method of teaching in control group, a post test on Problem solving ability has been carried out on both groups. The treatments on both experimental and control group are graphically represented as in Figure 15

Figure 15

Graphical Representation of Treatments in Different Phases on both Experimental and Control Group



Variables of the Study

Variables are the conditions or the characteristics that the experiment manipulates, controls or observes (Best & Khan, 2010). Normally an Experimental study will have Independent Variables, Dependent Variables and Control variables. Those variables in this study are briefly described here.

Independent Variable

Independent variables are the conditions or characteristics that the experimenter manipulates or control in his or her attempt to ascertain their relationship to observed phenomena (Best & Khan, 2010). Independent variables are brought as treatments to which experimental groups are exposed. So, it is also named as treatment variable.

The Independent Variable for the present study is the Instructional strategy. The two levels of the Instructional Strategy used were as follows.

- Virtual Learning Environment using Geogebra
- Conventional Instructional Strategy

Virtual Learning Environment using Geogebra is an Instructional Strategy designed and developed by the investigator incorporating Geogebra as the major element. Various features of Geogebra like visualization, construction, 3D effects, creating whole with constituent parts, unfolding whole to parts are being utilized here. Each modules in Virtual Learning Environment contained introduction, illustration, and evaluation elements. The Virtual Learning Environment also included other multimedia elements such as animations, videos, interactive quizzes, images etc. to teach geometry for Secondary School Students.

Conventional Instructional Strategy refers to the method of teaching adopted by Secondary School teachers of Kerala to transact the curriculum prescribed by SCERT, Kerala.

Dependant Variable

Dependent variables are the conditions or characteristics that appear, disappear or change as the experimenter introduces/removes or change independent variables (Best & Khan, 2010). They are measured before and after the treatment to see whether any changes occurred. The dependent variable may be a test score, the number of errors or measured speed in performing a task (Best & Khan, 2010).

Dependent Variable measured in the present study is ‘Problem Solving Ability in Geometry’.

The dependent variable Problem Solving Ability is measured as the total score of its four components viz., Understanding the problem, Mapping the problem Identifying relationships and Finding the solution.

Control Variable

Control variables refer to variables that are not of primary interest i.e., neither the exposure nor the outcome of interest and thus constitute an extraneous or third factor whose influence is to be controlled or eliminated. These variables are the covariates which can be controlled statistically.

Control variable considered in the present study is

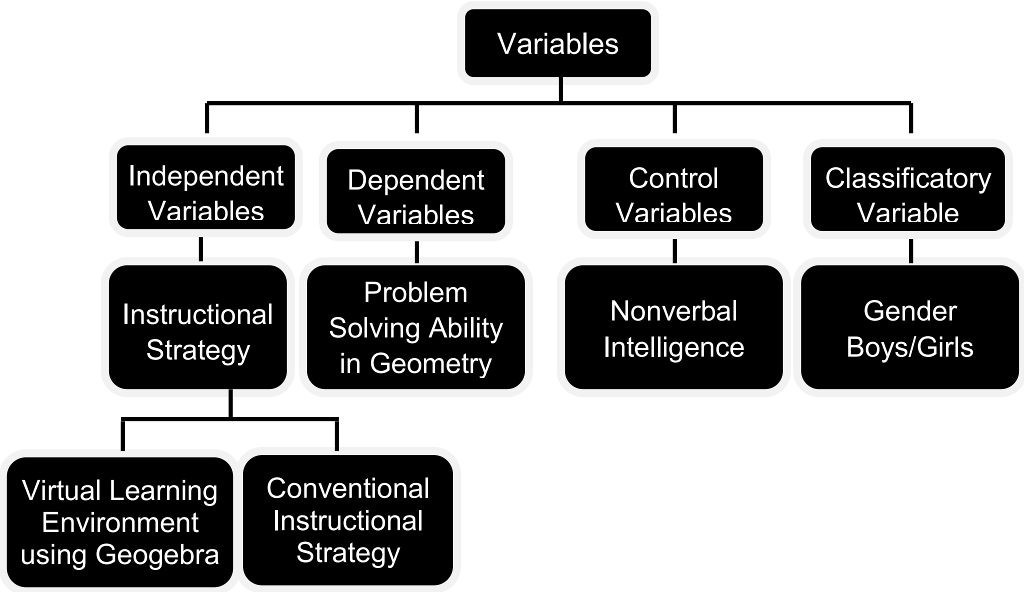
- Nonverbal Intelligence

Nonverbal intelligence is the ability to analyze information and solve problems using visual or hands-on reasoning. People with nonverbal intelligence will be skilled in understanding the meaning of visual information and recognize relationships between visual concepts. Nonverbal intelligence is very significant as far as Mathematics and geometry is concerned since it helps in conceiving and implementing two dimensional and three dimensional designs and solving problems in geometry. Nonverbal intelligence cannot be controlled physically, but its influence can be controlled statistically by using ANCOVA.

A diagrammatic representation of the variables in the study is given in the figure 16

Figure 16

Diagrammatic Representation of the Variables Selected for the Study



Objectives of the Study

General Objectives

1. To develop a Virtual Learning Environment using Geogebra on Geometry for secondary school students.
2. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School students

Specific Objectives

1. To find out the effect of Virtual Learning Environment using Geogebra on first component of Problem Solving Ability (Understanding the Problem) in

Geometry of Secondary School students for the total group and subgroups based on gender.

2. To find out the effect of Virtual Learning Environment using Geogebra on second component of Problem Solving Ability (Mapping the Problem) in Geometry of Secondary School Students for the total group and subgroups based on gender.

3. To find out the effect of Virtual Learning Environment using Geogebra on third component of Problem Solving Ability (Identifying relationships) in Geometry of Secondary School Students for the total group and subgroups based on gender.

4. To find out the effect of Virtual Learning Environment using Geogebra on fourth component of Problem Solving Ability (Finding the solution to the problem) in Geometry of Secondary School Students for the total sam group and subgroups based on gender.

5. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability (Total) in Geometry of Secondary School Students for the total group and subgroups based on gender.

6. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on first component of Problem Solving Ability (Understanding the Problem) in geometry of Secondary School Students for the total group and subgroups based on gender.

7. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on second component of Problem Solving Ability (Mapping the Problem) in

geometry of Secondary School Students for the total group and subgroups based on gender.

8. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on third component of Problem Solving Ability (Identifying relationships) in geometry of Secondary School Students for the total group and subgroups based on gender.
9. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on fourth component of Problem Solving Ability (Finding solution to the problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
10. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Nonverbal intelligence as covariate, on Problem Solving Ability (Total) in Geometry of Secondary School Students for the total group and subgroups based on gender.

Hypotheses of the Study

1. Virtual Learning Environment using Geogebra has significant effect on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender
2. Virtual Learning Environment using Geogebra has significant effect on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender
3. Virtual Learning Environment using Geogebra has significant effect on ability to Identify Relationships in the problem in Geometry of Secondary School Students for the total group and subgroups based on gender

4. Virtual Learning Environment using Geogebra has significant effect on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender
5. Virtual Learning Environment using Geogebra has significant effect on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender
6. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
7. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
8. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Identify Relationships in the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
9. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Find Solution to the problem in Geometry of Secondary School Students for the

total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

10. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Samples Selected for the Study

Sampling is the process by which a relatively small number of individual objects or events are selected and analyzed in order to find out something about the entire population from which it is selected. Sampling procedures provide generalizations on the basis of a relatively small proportion of population (Koul, 1997). The purpose of sampling is to gain information about a population. The population of the study is IX standard students of Secondary Schools. The method adopted for the study was experimental. A total of 90 students from two divisions of standard IX of Al- Anvar High School Kuniyil, Malappuram District of Kerala state were selected for the conduct of the study. Subjects were not assigned randomly since intact classrooms were assigned as experimental and control groups to conduct the experimentation without collapsing the order of functioning of the school. So the study adopted Quasi Experimental Pre-test Post- Test Nonequivalent group design.

Piaget described age 12+ as the formal operational stage, where the children develop the capacity to understand abstract concepts and engage in systematic logical reasoning and Problem solving (Banerjee, 2011). Also Standard IX covers adequate and appropriate content of Geometry in the curriculum, considering both these reasons students of IX standard has been chosen as samples. Both experimental group and control groups were selected from the same school for the study for minimizing the effects of school environment on experimentation. One intact ninth standard classroom for experimental group and one intact ninth standard classroom for control group were selected. Number of subjects in the experimental and control groups were 44 and 46 respectively. Break up of sample selected for the study is shown in Table 1

Table 1

Break up of Sample Selected for the Study

Group	Boys	Girls	Total
Experimental Group	18	26	44
Control Group	31	15	46
Total	49	41	90

Tools used for the Study

Gathering of data from the group on whom the study is intended is a very significant element in every research. In order to satisfy this need every researcher should have appropriate and perfect devises. Those devises are generally called as Tools. Aggarwal (1966) defined tool as “The instruments employed as a means to gather new factors to explore new fields”. If the tools selected are not appropriate, even the credibility of the research may be questioned. So employing appropriate tool is an inevitable requirement towards the fulfillment of objectives in the research carried out. The researcher has to develop a new tool or modify an existing tool or adopt a tool as such to collect the required data for the investigation.

The tools employed for this research are as follows,

1. Problem Solving Ability Test in Geometry (Rishad & Praveen, 2019)
2. Virtual Learning Environment with Geogebra (Rishad & Praveen, 2019)

3. Lesson Transcripts on Conventional Instructional Strategy (Rishad & Praveen, 2019)
4. Standard Progressive Matrices Test (Raven, 1958)

Tools employed in the research are described below.

Description of the Tools

1. Problem Solving Ability Test in Geometry (Rishad & Praveen, 2019)

Though there are plenty of studies on scientific problem solving, none of them directly mention the components of Problem solving. Many authors who have studied on problem solving ability put forth various steps in problem solving, but the components were not being explored much (Praveen, 2018). (Praveen, 2018) Identified three major components for Problem solving ability Viz. Comprehending the Problem, Clarifying the Problem and Finding Solution to the Problem. Each component has its subcomponents. The first major component viz; comprehending problem represents the initial stage of acquainting with the problem. To attack it intellectually one has to build a rapport with the structure of the problem. Comprehending involves mental processes, which would help the problem solver to evolve a more concrete structure of the problem. The second major component viz; Clarifying the problem is an attempt to untangle the intricacies of the problem so as to attack the problem intellectually. Clarifying involves mental processes of employing common thinking strategies, which would help the researcher to solve the problem. The third major component of Problem Solving Ability is Finding Solution to the Problem. This component includes cognitive efforts to experiment, infer and generalize.

From the reviews and by assimilating the theories and consultation with the experts the investigator, formulated the components of Problem solving Ability as discussed below.

Components of Problem Solving Ability

The major components identified by the investigator as mentioned above are,

- Understanding the problem
- Mapping the problem
- Identifying relationships
- Finding the solution

The cognitive skills that contribute each components are discussed below:

Understanding the Problem. Whenever the learner confronts a problem the first and foremost thing to do in solving the same is to know the problem well. Only if he could understand the problem he can go ahead with the problem in search of its solution. At this stage the learner, knows, defines, and comprehends the problem well.

The manner in which the problems are represented to the learners plays an important role in developing conceptual understanding. For recognizing the structure of the problem quickly, the solvers have to identify the attributes of external problem representation and they must be mapped onto the learner's mental representation (Jonassen, 2004). The form of the external representation of problem affects the cognitive process of problem solving. Therefore, in order to develop adequate conceptual understanding of the class of problems, learner must perceive the form, organization and sequence of problem representation.

The cognitive skills that contribute Understanding the Problem include understanding situational characteristics of the problem, drawing situational diagram of the problem, drawing the structure map that connects the concepts embedded in the problem, Searching for keywords within the problem, comprehension of relevant textual information in the problem, etc.

Mapping the Problem. Here the learner is able to visualize the problem and create a map of the same in his mind. The image formed in the minds of the learner well assist the learner in designing the strategy to its solution.

The cognitive skills that contribute the component Mapping the Problem are finding conceptual relationships (schema) in the problem, capacity to visualize data, understanding quantitative relationships in the problem, understanding structural characteristics of the problem, selecting appropriate algorithm for the problem, representing unknowns in the problem with letters, capacity to recognize deep structure of the data in the problem, etc.

Identifying Relationships. Analysis of the situation is a primary requirement for solving any problem. While analyzing the situation the individual will be able to find out relationship between the elements of the subject matter, data, known and unknown facts etc. so the capacity to identify relationships is a key skill to be acquired to become good problem solvers.

The cognitive skills that contribute the component Identifying relationships include, combining data with situational diagram and conceptual relationship in the problem, deciding upon relationships among data sets such as =, <,> etc. in the problem, translating relationships about unknown variable into questions, capacity to correctly sequence the relationships etc.

Finding the Solution. To reach at the right solution all elements of problem solving should work out in proper manner. This component includes the cognitive effort to experiment, infer, verify and generalize.

The cognitive skills that contribute the component Finding the solution are, applying correct algorithm towards the solution of the problem, verifying the correctness of the solution of the problem, reflection by ascribing values including solution on to the situational diagram etc.

Design of the Test

This Test was developed and standardized by the investigator with the help of the supervising teacher and in consultation with experts in the field. The details of the procedure involved in the development of the test is given below.

Preparation of Draft Test. The investigator reviewed books, Thesis, Journals, periodicals, Mathematics textbooks and other descriptive materials to construct the items for the Problem Solving Ability Test in Geometry. Experts in the field were also consulted and their suggestions were taken into consideration.

After discussion with supervisor and review process, the investigator identified 35 questions to test the problem solving ability of the students. All questions were prepared by giving due weightage for all the components identified, viz. Understanding the problem, Mapping the problem, Identifying relationships, Finding solution. The draft of the Problem Solving Ability test was prepared such that each component of the Problem Solving Ability is tested in all questions. Subsequently 18 questions were selected and subjected for Item Analysis.

Item Analysis. On the basis of the identified components of problems solving ability, ie., Understanding the problem, Mapping the problem, Identifying relationships and Finding the solution, an initial tool having 18 test items have been constructed and which is then given to a group of experts in the field of Mathematics teaching along with an evaluation matrix form. As requested by the investigator, the experts were marked their rating of evaluation regarding each items of the test with necessary comments. Based on their suggestions, 3 items were eliminated and others were retained. The investigator took care in avoiding ambiguous and indefinite test items.

A copy of the evaluation matrix and list of experts is attached as Appendices VII and IX respectively

Pre tryout. After preliminary screening and editing of the items, the tools was pre tried out on 10 students of secondary school in order to find out the accuracy and relevance of each items. After this preliminary administration of the test with the consultation of the supervising teacher, minor changes were made in the language and sentence constructions in some of the items. It was also ascertained that the vocabulary used in the test item was appropriate for secondary school students.

Try- out. After pre-try out, the test was administered on a sample of 100 secondary school students in order to find out the feasibility of the test items with due representation to all subsamples. Clear instructions were given to them. They were asked to answer all the questions without omitting any item of the test. The investigator ensured the appropriateness of the test items through this process.

Preparation of the Final Test. Out of the 18 items included in the Item analysis 15 were selected for the final test. The test contained two parts. Detailed instructions for the students has been given in the first part of the test. The second part includes, 15 questions to test the problem solving ability of the students. Each question have 4 sub questions viz. A, B, C and D. The sub questions were prepared so as to use the capacities of each components of problem solving ability. Each sub question carried 1 marks and the total mark for one question was 4. In such a way the test have 60 items and total score of 60.

The final tool consisting of the selected items was printed with all necessary instructions. Malayalam and English version of the final tool is attached as appendices I and II respectively.

Reliability of the test. Test-retest method was being used for establishing the reliability of the test. As the initial step, the problem Solving test was administered on 60 students of Al- Anvar High school, Kuniyil. The same test is administered on them after 2 weeks from the date of first administration. The scores of 50 students who have attended both tests were considered for determining the reliability. Reliability was then determined by using Pearson's product moment coefficient of correlation formula for the test as a whole and for the 4 components separately. The correlation coefficient of the Problem solving test obtained was reasonably high which shows that the test is highly reliable. Table 2.

Table 2

Component wise Values of Pearson's Product Moment Coefficient of Correlation of Problem Solving Ability Test

Name of the test/components	Pearson's Correlation Coefficient (N=50)
Problem Solving Ability Test in Geometry	0.82
Understanding the Problem	0.78
Mapping the Problem	0.69
Identifying relationships	0.74
Finding Solution to the Problem	0.73

Validity of the Test. Validity of a test clearly reflects what it is intended to measure. Validity of the test was taken care of while giving weightage to components. During preparation of items, opinions of experts (Appendix No. IX) were given due significance.

Content Validity. The test was prepared with due theoretical support in identifying the components of Problem Solving ability with the close mentoring and supervision of experts in the field. More over the items were prepared in such a way to reflect the real intention of testing particular components. So the problem solving ability test in geometry is said to have content validity.

Face Validity. Face validity was established on the recommendations of subject experts as it is examined and approved by them. Extreme care was taken to avoid any sort of ambiguity in wording of the item. Hence it can be ensured that the tool is valid in its outlook.

2. Virtual Learning Environment Using Geogebra (Rishad & Praveen, 2019)

Recent changes in Education have been characterized by increased expectations from large-scale use of Information and Communication Technology (ICT). Application of ICT and virtual means have highest acceleration in the entire levels of learning especially in schooling. In this context, Virtual Learning Environments (VLEs), also referred to as Learning Management Systems (LMSs), Content Management Systems (CMSs) or online learning environments, were launched as a way of responding to the new set of educational demands. VLEs have been defined as learning management software systems that synthesize the functions of computer-mediated communications software and online methods of delivering course materials (Britain & Liber, 2004). One of the most important reasons given for the large-scale investment in web based technology is their potential to enhance teaching and learning (Jenkins, Browne & Armitage, 2001), as well as to encourage the development of student-centred, independent learning (Pahl, 2003) and to foster a more deep approach to learning (Collis, 1997).

Enhancement of learning was previously found to be linked with the adoption of student-centred approaches to teaching and learning in traditional contexts. Education researchers approached an understanding of students' learning by assessing students' experiences of learning and how they made sense of the individual approach to the tasks prescribed by their course of study. Marton and Saljo (1976) had first identified a deep and a surface level of processing, each of them corresponding to contrasting focuses of attention. The term *approach* included intention, which is what the learner was looking out for but also process, which is how that intention was carried out. It was evidenced that a deep approach was likely to result from a relevance to students' interests (Fransson, 1977), the interest, support and enthusiasm of the instructor and where students had an opportunity to manage their own learning (Ramsden & Entwistle, 1981). Conversely, a surface approach was more likely to emerge when assessment methods rewarded reproducing information, anxiety or a heavy workload (Ramsden & Entwistle, 1981). Further work has identified another component; the strategic approach which derives from an intention to obtain the highest possible grades and involves focusing on assessment requirements and task demands, as well as adopting well-organised and efficient study methods (Entwistle, 1992). Overall, it was proposed that a relationship existed between higher quality learning outcomes and a deep approach to learning (Marton & Saljo, 1997), and between a deep approach to learning and a student-focused approach to teaching (Trigwell et al., 1999).

Since the introduction of VLEs, it has been unclear whether these findings apply also to web-enhanced learning environments. It has been argued, however, that a transfer of traditional teaching methods to the online context may ignore pedagogical issues and also that the central provision of VLEs promotes a degree of pedagogical inflexibility (Konrad, 2003). Despite the introduction of evaluation methodologies for learning technologies (Oliver, 2000), others claimed that the role of the individual learner and the dynamic characteristics they bring into this particular learning situation, was widely overlooked (Richardson, 2001; Hoskins & vanHooff, 2005).

Some studies attempted to explore the relationship between students' approaches and use of VLEs and provided a basic overview of the subject. In one of those studies, the Approaches and Study Skills Inventory for Students (ASSIST) (Tait et al., 1998) had been used, with the aim of examining whether the students' approach to learning affects their perception of the value of the VLE. It was concluded that students who adopted a deep approach to learning showed a preference for independent studying and perceived positively the use of the VLE. On the contrary, students who developed a surface approach complained about lack of time and had not completed the online tasks set (Jelfs & Colbourn, 2002). A similar study in the same university, found that there was a negative correlation between a surface approach and the rating of the VLE (Enjelvin & Sutton, 2004).

Adopting a different perspective on the issue, an investigation with Social Sciences students questioned to what extent the use of a VLE could contribute to the demonstration of a deep approach to learning. Participants in discussions had higher deep learning scores whilst non-participants had higher surface approach scores. Evidence was also reported that strategic learners demonstrated their approach by their choice of online activities, which required flexibility in learning and organizational skills (Gibbs, 1999). Finally, in a most recent study, Hoskins and van Hooff (2005) reported that strategic approach was associated with more extended use of bulletin boards.

Instructional Design for Virtual learning Environment

VLEs are shaped in many ways and most importantly by their designers. It has been indicated that VLEs are not value-free (McNaught & Lam, 2005) and that there are specific values inherent not only in their design philosophy but also in their implementation and use. The argument highlights the significance of informed choices in the process of design and use of VLEs, particularly with regard to the enhancement of deep approaches to learning and the achievement of high quality learning outcomes. If the benefits of deep learning in a conventional teaching context may apply to an online learning environment, it could be contended that design and appropriate practice may also encourage student motivation and promote deep learning through appropriate use of VLEs.

ADDIE Model of Instructional Designing

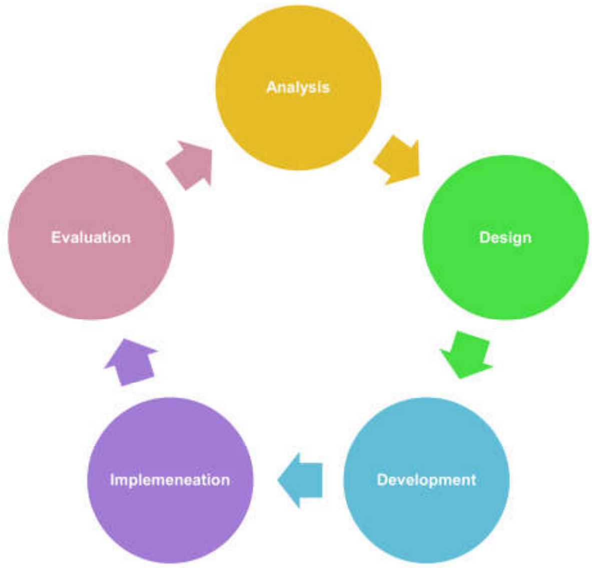
The ADDIE model is an instructional design framework commonly used to develop courses and streamline the production of training material. The concept was created in 1975 by the Center for Educational Technology at Florida State University for the U.S. Army. Shortly after its inception, the ADDIE training model was adapted by the U.S. Armed Forces (Branson et al., 1975).

According to the ADDIE process, there are five phases or stages in the creation of tools that support training: analysis, design, development, implementation, and evaluation. The original goal of the process was to increase the effectiveness and efficiency of education and training by fitting instructions to jobs and providing instruction in areas most critical to job performance (Allen, 2006).

Phases of ADDIE Model. The ADDIE process is a systematic instructional design model that includes five steps or phases. Each phases are briefly discussed below. A diagrammatic representation of the ADDIE model is given in figure 17

Figure 17

Phases of ADDIE Model



Analysis. Muruganantham (2015) claims that the analysis phase is the foundation of all other phases of instructional design, including the ADDIE process. At this initial stage, potential instructional problems and objectives are identified. Learners' existing knowledge and skills are also evaluated to determine the type and extent of instruction needed.

Muruganantham (2015) further points out that the analysis phase can include specific research techniques such as needs analysis, goal analysis, and task analysis. A needs analysis technique, for instance, will help instructional designers determine the resources required and the potential constraints of their plans of action.

Mayfield (2011) further suggests that results from prior learning modules or courses should be used as input for the analysis phase. By the end of the analysis phase, learning goal targets should be determined, along with available resources for module deployment.

Design. In the design phase of the ADDIE model, instructional designers map out the process of how learners will achieve the desired learning objectives.

According to Kurt (2017), the design phase should be executed with a systematic approach, following a specific set of rules.

Data collected or obtained during the analysis phase serves as input for the design phase, helping instructional designers choose instruction strategies and materials that will be most effective for the learners involved (Arkun & Akkoyunlu, 2008). Timeframes for learning activities and feedback mechanisms are also determined at this stage of the ADDIE model.

Additionally, during this phase, potential instruction strategies are tested (Allen, 2006). Existing instructional materials are also reviewed. This helps instructional designers determine if the materials are applicable to the plans under development.

Development. At the development phase, instructional designers get to work, creating the assets and materials described in the previous design phase. The created content includes the overall learning framework, exercises, lectures, simulations, and other training materials (Mayfield, 2011)

After course materials are developed, designers also perform pilot tests where course materials and instructional methods are rehearsed (Davis, 2013). Feedback from these pilot tests can help identify weaknesses and enhance the entire program before implementation.

Implementation. The implementation phase of the ADDIE model deals with the actual delivery of the program or course to the learners. According to Morrison et al. (2007), there are three steps to the implementation phase of the ADDIE training process:

- Training educators to increase their understanding of the course content and materials

- Arranging the learners to ensure they have access to the materials and tools they need to complete the program's activities and ensure the expansion of their knowledge
- Setting up an environment that is conducive to learning

While learners consume the materials developed in the previous phases, instructors must ensure that learners understand the material and achieve the learning objectives. More importantly, instructors must observe and document students' performance as well as their attitudes and behaviors towards the learning process (Yeh & Tseng, 2019). These observations serve as valuable inputs for the process' evaluation phase.

Evaluation. The evaluation phase measures the effectiveness and efficiency of the instructional program. In revised ADDIE models, evaluation is the centrepiece of the process (Allen, 2006). The evaluation process starts with the analysis phase and continues throughout the lifecycle of the learning program.

According to Allen (2006), the evaluation phase consists of:

- formative evaluation, where products and processes are evaluated at each stage of the ADDIE process to ensure quality and continued progress
- summative evaluation, which focuses on the outcome of the learning program as a whole and includes an assessment of the program's overall effectiveness

Allen (2006) further argues that the entire ADDIE process takes place within the framework of continuous quality improvement. As instructional designers move through the different phases of the ADDIE training model, the processes used and outcomes of each phase are evaluated against instructional requirements and principles of learning.

Instructional Design for Virtual Learning Environment using Geogebra

In tune with the ADDIE model of instructional designing and through discussion with experts, the investigator developed a Virtual Learning Environment using Geogebra to teach geometry in 9^{th} standard. The various phases involved are discussed below,

Analysis Phase. In the analysis phase, for the development of the Instructional strategy Virtual Learning Environment using Geogebra, the investigator selected the chapter 'Prisms' of standard IX Mathematics text book prepared as per SCERT curriculum followed in Kerala state. The content is analyzed in detail in terms of facts, concepts, principles, generalization etc. Analysis for pre-requisites, skills required for new learning, Strategies for providing learning experiences, multimedia elements were also done.

Design Phase. In this phase design of the Instructional strategy, Virtual Learning Environment using Geogebra has been formulated. The VLE has been designed by incorporating problem solving approach. Appropriate introduction, presentation style and assessment procedures were designed. Various features of Geogebra like visualization, construction, 3D effects, creating whole with constituent parts, unfolding whole to parts are identified. Areas, where various multimedia elements, such as animations, videos, interactive quiz, images can be integrated are clearly identified with time frame. The entire content area has been divided into six modules and scripts for all modules has been prepared, so as to develop the original digital module. A sample lesson transcript and a sample script of a module has been attached as Appendices V & VI.

Development Phase. As per the preparations and activities done in the analysis and design phases, Virtual Learning Environment using Geogebra has been developed in this phase. Technical expertise of web designer has been made use for making the VLE a reality. The VLE has been named as 'EasyGeo'. The VLE has been developed so as to work offline as of now and it can be authored to work in online too. The modules in the VLE contains introductory, presentation and assessment elements. Features of Geogebra like visualization, construction, 3D effects, creating whole with constituent parts, unfolding whole to parts are being applied wherever required. Problem solving approach and multisensory approach has been utilized in the development of the Virtual Learning Environment. Geogebra applets prepared by the investigator, Interactive quizzes, Animations, videos, images etc. have been integrated throughout out the modules. Assessment questions and its solution has been given wherever necessary. Since the platform need a browser to work, it has been developed using HTML**.** The VLE so developed was sought for the expert opinion of resource persons in Geogebra and teachers of Mathematics. Modifications has been carried out in VLE as per the suggestions of the experts. Details of the modules in the VLE are as shown in the table below.

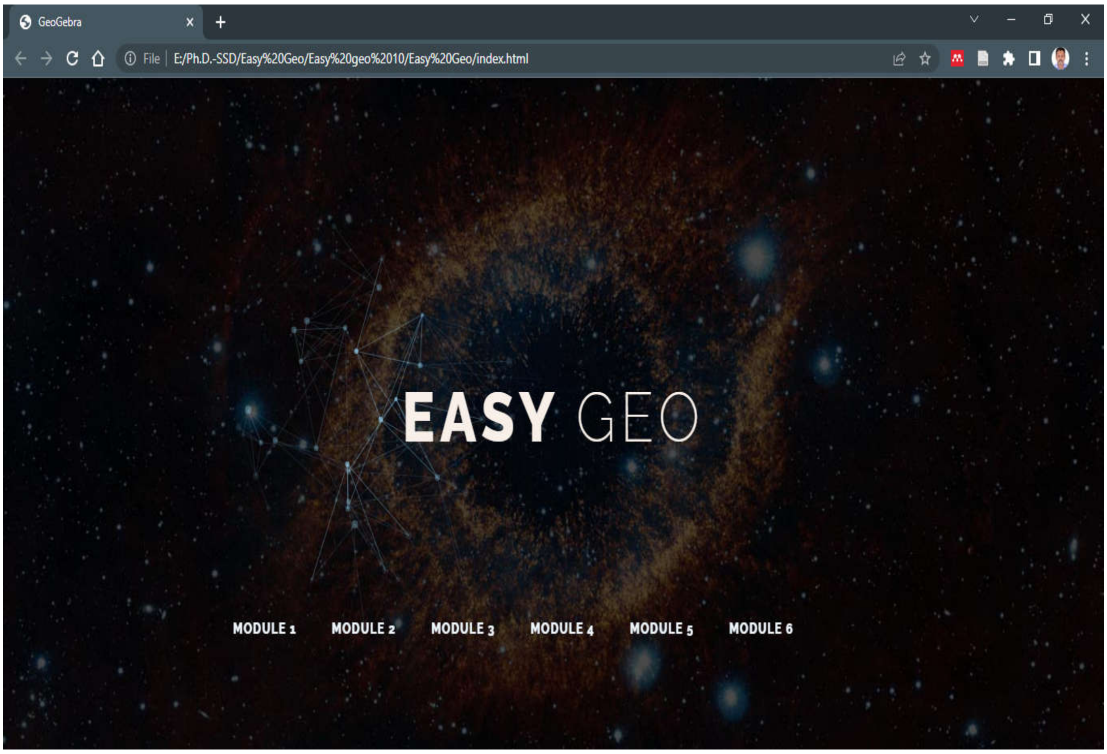
Table 3

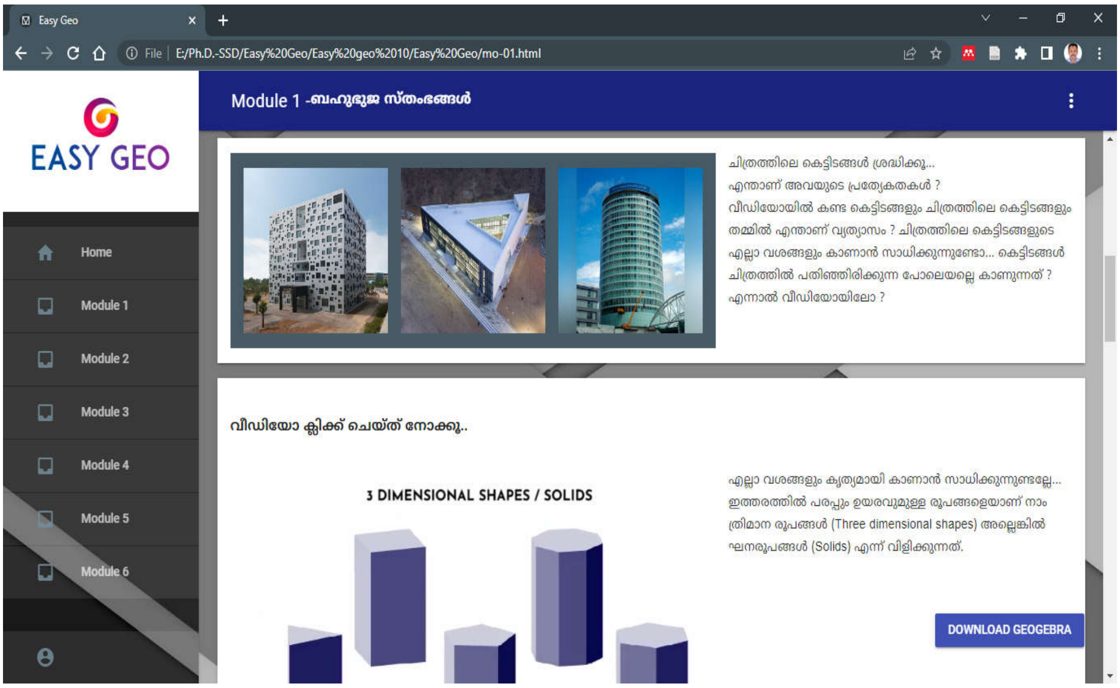
Modules in the Virtual Learning Environment

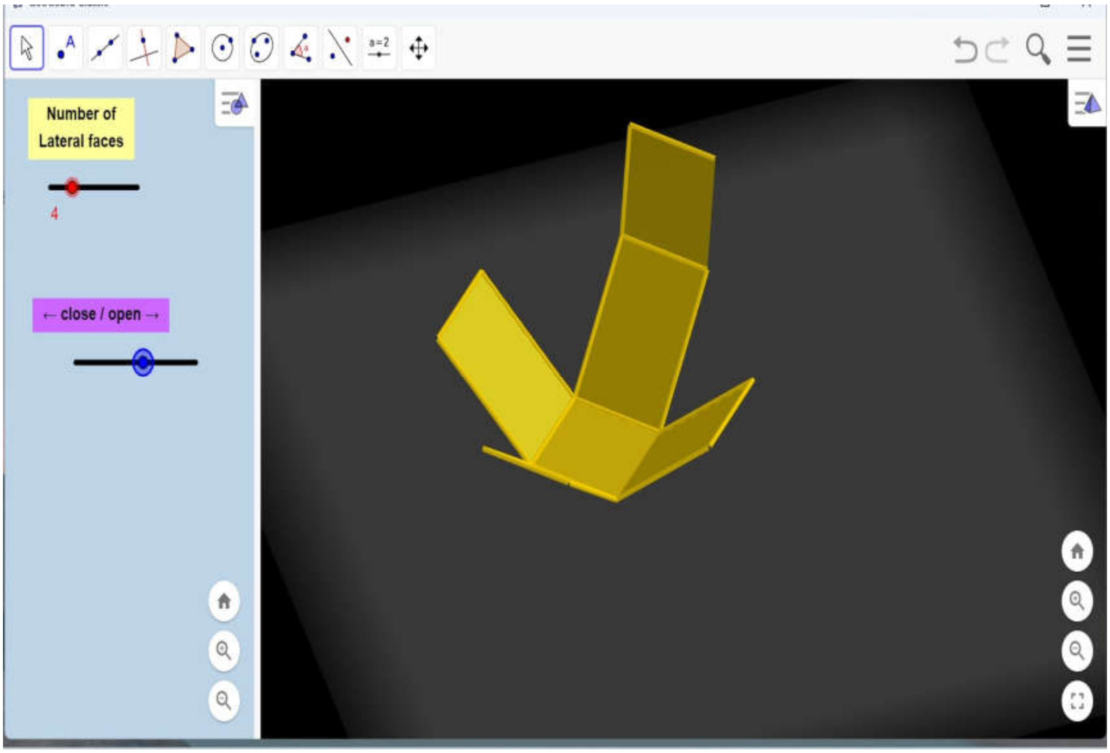
Module No.	Name of the Module
1	Introduction to Prisms
2	Volume of Prisms
3	Lateral Surface area of Prisms
4	cylinder
5	Volume of a cylinder
6	Curved surface area of a cylinder

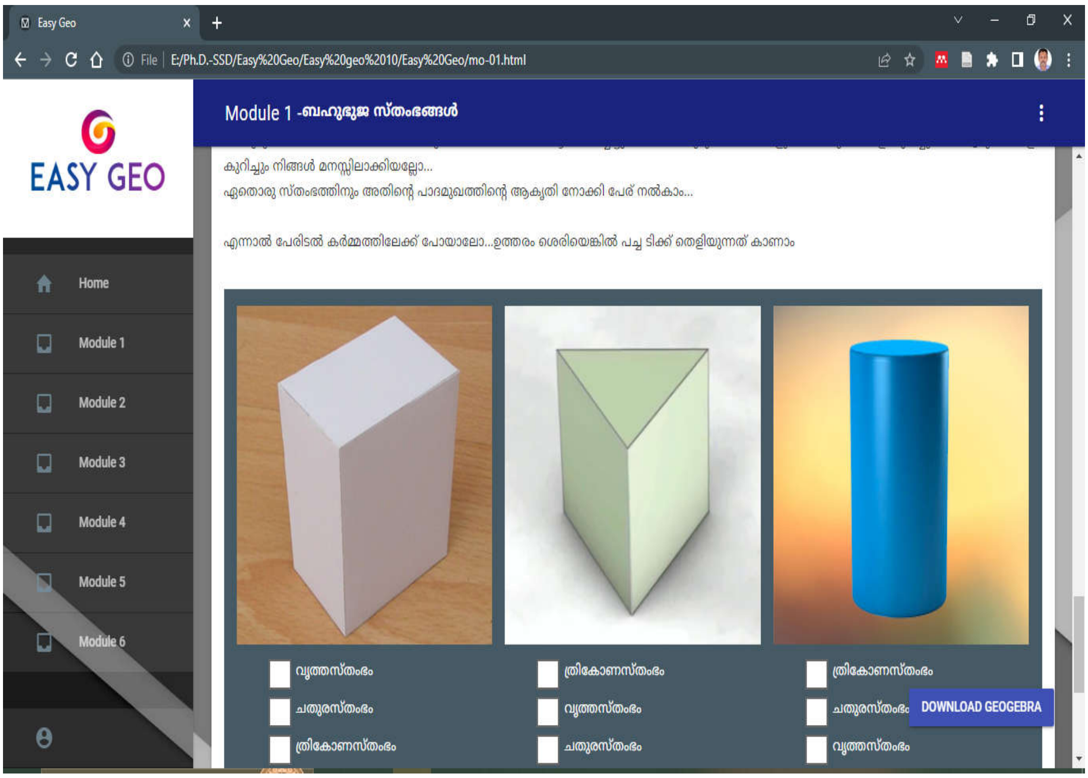
Screen shots of some of the user interfaces of various modules in EasyGeo Virtual Learning Environment are given below

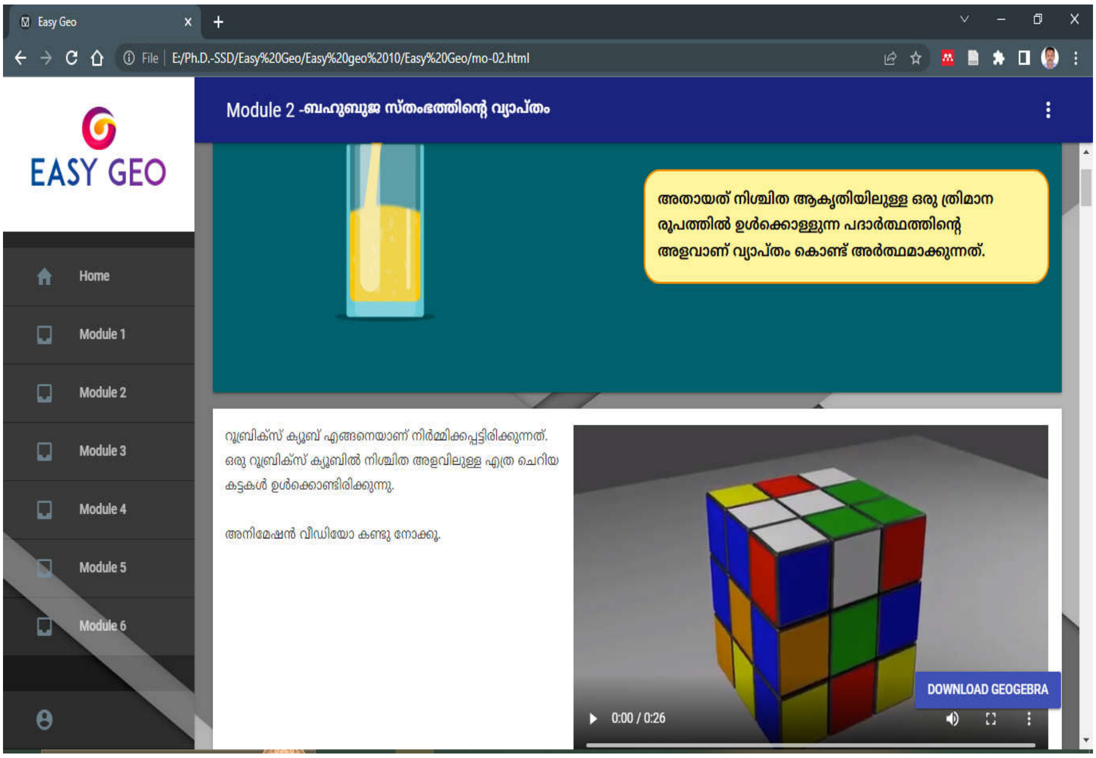
Screen Shorts of Various Modules in the VLE

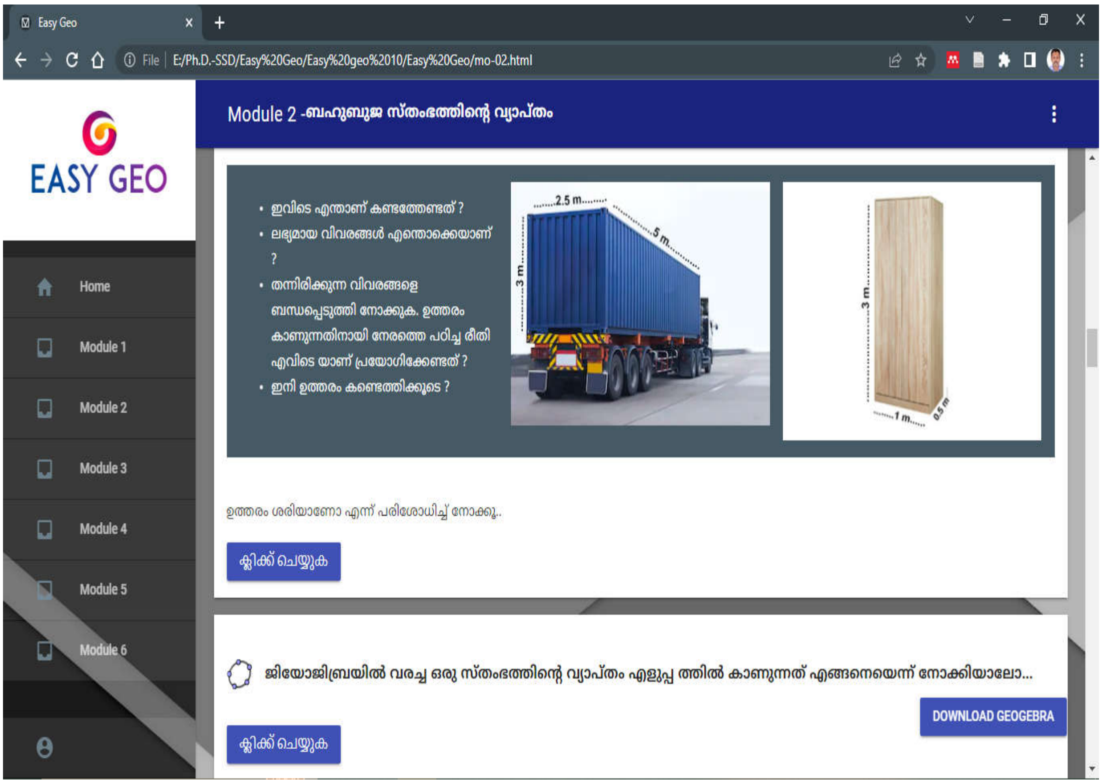


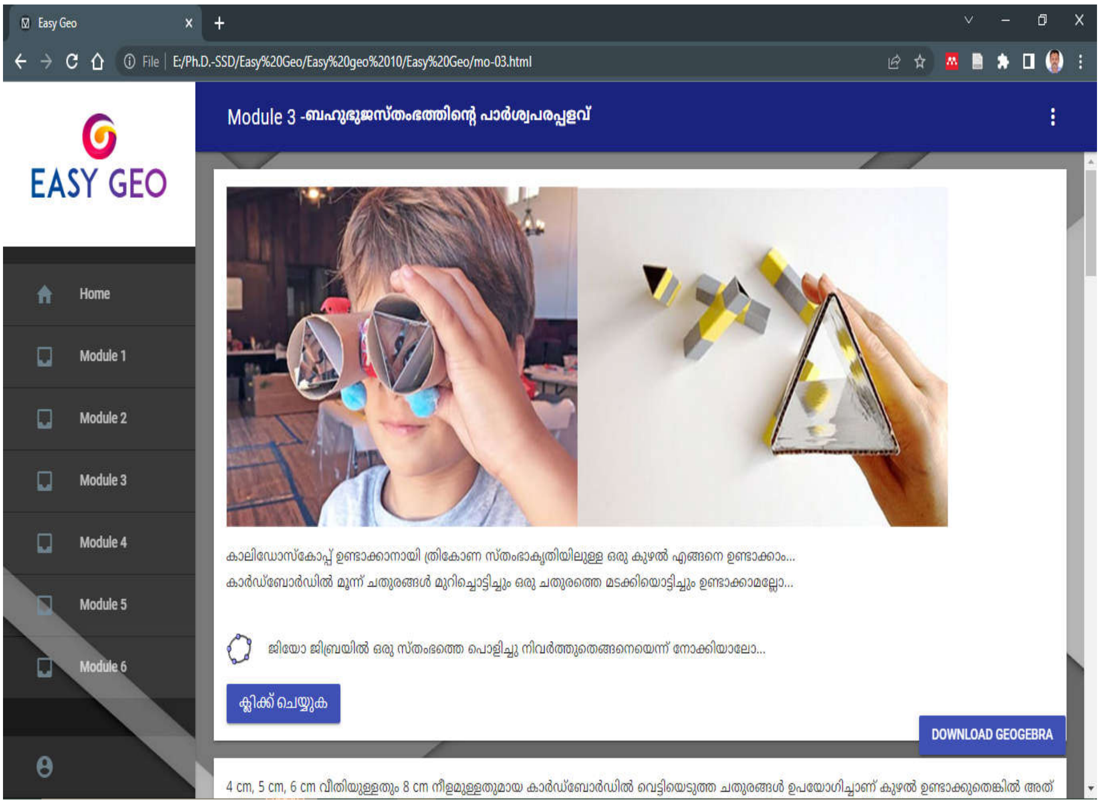


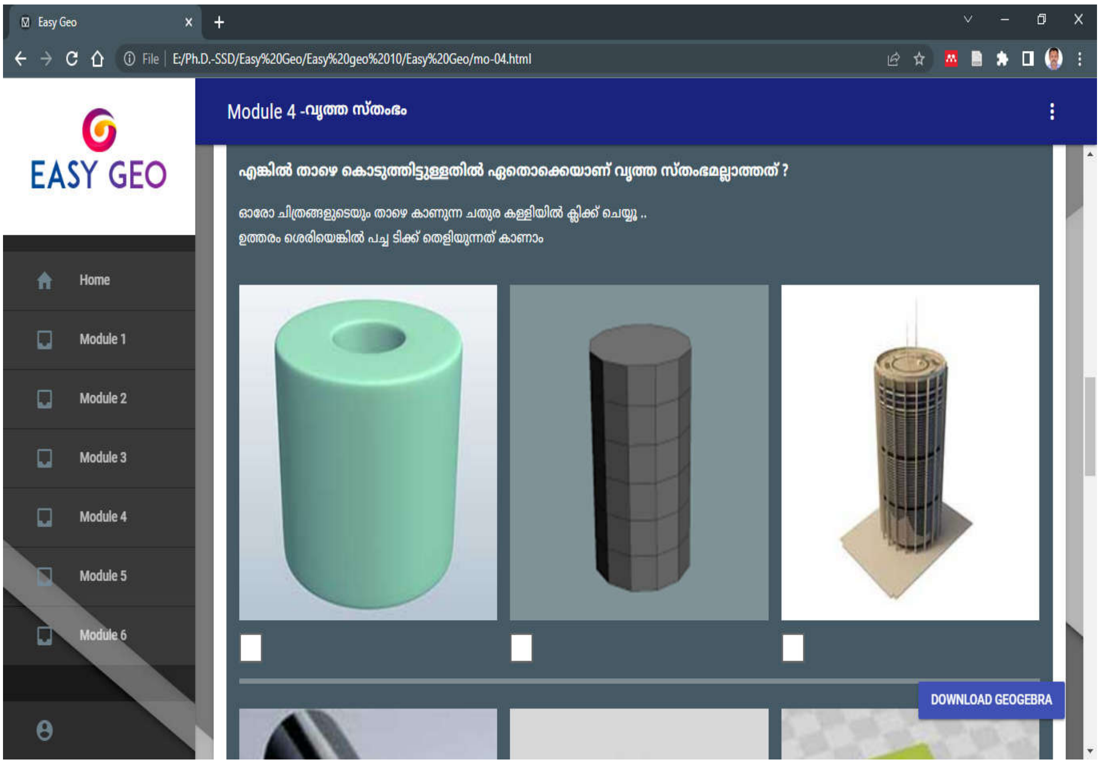

Number of
Lateral faces
4
← close / open →

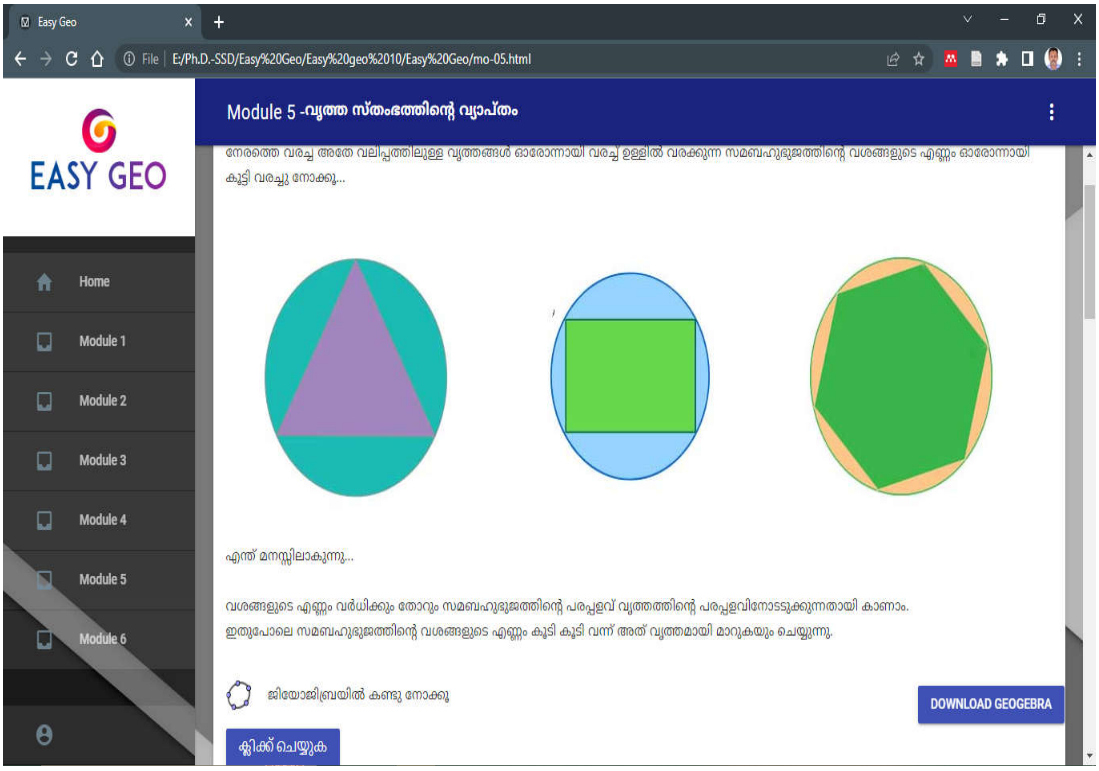

Easy Geo
File | E:/Ph.D.-SSD/Easy%20Geo/Easy%20geo%2010/Easy%20Geo/mo-01.html
EASY GEO
Module 1 -ബഹുഭുജ സ്തംഭങ്ങൾ
കുറിച്ചും നിങ്ങൾ മനസ്സിലാക്കിയല്ലോ...
ഏതൊരു സ്തംഭത്തിനും അതിന്റെ പാദമുഖത്തിന്റെ ആകൃതി നോക്കി പേര് നൽകാം...
എന്നാൽ പേരിടൽ കർമ്മത്തിലേക്ക് പോയാലോ...ഉത്തരം ശെരിയെങ്കിൽ പച്ച ടിക്ക് തെളിയുന്നത് കാണാം
Home
Module 1
Module 2
Module 3
Module 4
Module 5
Module 6
വൃത്തസ്തംഭം
ചതുരസ്തംഭം
ത്രികോണസ്തംഭം
ത്രികോണസ്തംഭം
വൃത്തസ്തംഭം
ചതുരസ്തംഭം
ത്രികോണസ്തംഭം
ചതുരസ്തംഭം
വൃത്തസ്തംഭം
DOWNLOAD GEOGEBRA

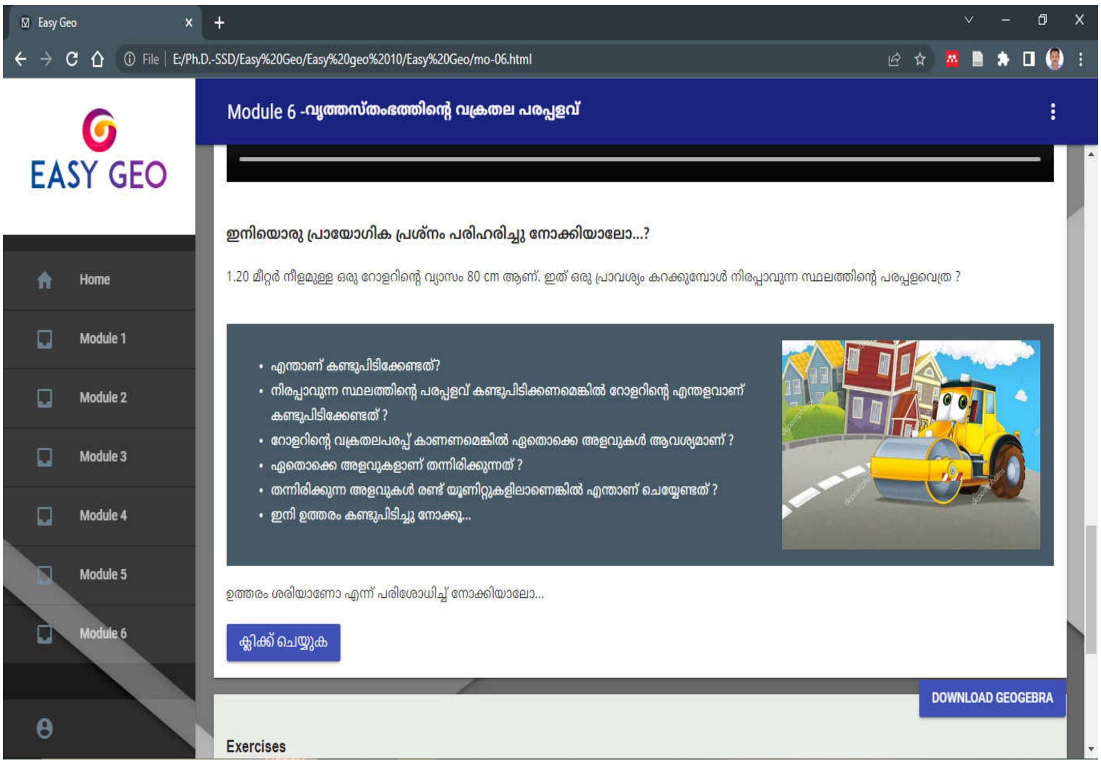

Easy Geo
E:/Ph.D.-SSD/Easy%20Geo/Easy%20geo%2010/Easy%20Geo/mo-02.html
EASY GEO
Module 2 -ബഹുബുജ സ്തംഭത്തിന്റെ വ്യാപ്തം
അതായത് നിശ്ചിത ആകൃതിയിലുള്ള ഒരു ത്രിമാന രൂപത്തിൽ ഉൾക്കൊള്ളുന്ന പദാർത്ഥത്തിന്റെ അളവാണ് വ്യാപ്തം കൊണ്ട് അർത്ഥമാക്കുന്നത്.
Home
Module 1
Module 2
Module 3
Module 4
Module 5
Module 6
റൂബിക്സ് ക്യൂബ് എങ്ങനെയാണ് നിർമ്മിക്കപ്പെട്ടിരിക്കുന്നത്. ഒരു റൂബിക്സ് ക്യൂബിൽ നിശ്ചിത അളവിലുള്ള എത്ര ചെറിയ കട്ടകൾ ഉൾക്കൊണ്ടിരിക്കുന്നു.
അനിമേഷൻ വീഡിയോ കണ്ടു നോക്കൂ.
0:00 / 0:26
DOWNLOAD GEOGEBRA


Easy Geo
E:/Ph.D.-SSD/Easy%20Geo/Easy%20geo%2010/Easy%20Geo/mo-02.html
EASY GEO
Module 2 -ബഹുബുജ സ്തംഭത്തിന്റെ വ്യാപ്തം
Home
Module 1
Module 2
Module 3
Module 4
Module 5
Module 6
• ഇവിടെ എന്താണ് കണ്ടെത്തേണ്ടത് ?
• ലഭ്യമായ വിവരങ്ങൾ എന്തൊക്കെയാണ് ?
• തന്നിരിക്കുന്ന വിവരങ്ങളെ ബന്ധപ്പെടുത്തി നോക്കുക. ഉത്തരം കാണുന്നതിനായി നേരത്തെ പഠിച്ച രീതി എവിടെ യാണ് പ്രയോഗിക്കേണ്ടത് ?
• ഇനി ഉത്തരം കണ്ടെത്തിക്കൂടെ ?
2.5 m
5 m
3 m
3 m
1 m
0.5 m
ഉത്തരം ശരിയാണോ എന്ന് പരിശോധിച്ച് നോക്കൂ..
ക്ലിക്ക് ചെയ്യുക
ജിയോജിബ്രയിൽ വരച്ച ഒരു സ്തംഭത്തിന്റെ വ്യാപ്തം എളുപ്പ ത്തിൽ കാണുന്നത് എങ്ങനെയെന്ന് നോക്കിയാലോ...
DOWNLOAD GEOGEBRA
ക്ലിക്ക് ചെയ്യുക


Easy Geo
File | E:/Ph.D.-SSD/Easy%20Geo/Easy%20geo%2010/Easy%20Geo/mo-03.html
EASY GEO
Home
Module 1
Module 2
Module 3
Module 4
Module 5
Module 6
Module 3 -ബഹുഭുജസ്തംഭത്തിന്റെ പാർശ്വപരപ്പളവ്
കാലിഡോസ്കോപ്പ് ഉണ്ടാക്കാനായി ത്രികോണ സ്തംഭാകൃതിയിലുള്ള ഒരു കുഴൽ എങ്ങനെ ഉണ്ടാക്കാം...
കാർഡ്ബോർഡിൽ മൂന്ന് ചതുരങ്ങൾ മുറിച്ചൊട്ടിച്ചും ഒരു ചതുരത്തെ മടക്കിയൊട്ടിച്ചും ഉണ്ടാക്കാമല്ലോ...
ജിയോ ജിബ്രയിൽ ഒരു സ്തംഭത്തെ പൊളിച്ചു നിവർത്തുതെങ്ങനെയെന്ന് നോക്കിയാലോ...
ക്ലിക്ക് ചെയ്യുക
DOWNLOAD GEOGEBRA
4 cm, 5 cm, 6 cm വീതിയുള്ളതും 8 cm നീളമുള്ളതുമായ കാർഡ്ബോർഡിൽ വെട്ടിയെടുത്ത ചതുരങ്ങൾ ഉപയോഗിച്ചാണ് കുഴൽ ഉണ്ടാക്കുന്നതെങ്കിൽ അത്


Easy Geo
File | E:/Ph.D.-SSD/Easy%20Geo/Easy%20geo%2010/Easy%20Geo/mo-04.html
EASY GEO
Home
Module 1
Module 2
Module 3
Module 4
Module 5
Module 6
Module 4 -വൃത്ത സ്തംഭം
എങ്കിൽ താഴെ കൊടുത്തിട്ടുള്ളതിൽ ഏതൊക്കെയാണ് വൃത്ത സ്തംഭമല്ലാത്തത് ?
ഓരോ ചിത്രങ്ങളുടെയും താഴെ കാണുന്ന ചതുര കള്ളിയിൽ ക്ലിക്ക് ചെയ്യൂ ..
ഉത്തരം ശെരിയെങ്കിൽ പച്ച ടിക്ക് തെളിയുന്നത് കാണാം
DOWNLOAD GEOGEBRA


Easy Geo
E:/Ph.D.-SSD/Easy%20Geo/Easy%20geo%2010/Easy%20Geo/mo-05.html
EASY GEO
Module 5
Home
Module 1
Module 2
Module 3
Module 4
Module 5
Module 6
DOWNLOAD GEOGEBRA


Easy Geo
E:/Ph.D.-SSD/Easy%20Geo/Easy%20geo%2010/Easy%20Geo/mo-06.html
EASY GEO
Module 6
Home
Module 1
Module 2
Module 3
Module 4
Module 5
Module 6
DOWNLOAD GEOGEBRA
Exercises

Implementation Phase. The Virtual learning environment using Geogebra thus developed was used for the intervention in the experimental group of the study. It has given different exposure to the students, since they have learned all the concepts through visual and interactive experiences. Though the VLE was self-instructional, a blended mode was used in the implementation, due to lack of enough technical facilities for individual learning. The learners who are treated with Virtual Learning Environment using Geogebra took hardly half of the time to complete the chapter 'Prisms' that of the time taken by the students in control group who are being taught through the conventional mode of teaching.

Evaluation Phase. Assessment questions provided in the Virtual Learning Environment to test the attainment of the concept itself makes a primary evaluation of the Virtual Learning Environment. Besides the expert's opinion, feedback from teachers of mathematics was sought during the implementation phase with the intention of further modification in the VLE, if necessary.

3. Lesson Transcripts on Conventional Instructional Strategy (Rishad & Praveen, 2019)

The investigator has prepared lesson transcripts on conventional Instructional strategy ie., the existing method of teaching followed by teachers of Mathematics working under general education department of Kerala state for teaching the control group. Lesson transcripts were prepared for the chapter 'Prisms' of 9th standard Mathematics on the basis of existing curriculum in Kerala state during the period of treatment 2019-20.

The investigator thoroughly analyzed textbook and teachers' handbook for the preparation of lesson transcripts. Also, the investigator consulted various Secondary School Mathematics teachers for suggestions and improvements in making the lesson plan. The lesson transcripts contained various elements of the lesson plan such as learning objectives, learning resources, pre-requisites, learning activities, follow-up activities and responses. The learning objectives describe the objectives to be attained by the students after the instruction of the particular lesson. Learning resources involve all the teaching learning aids that support the teaching learning process. Pre requisites lists the essential previous knowledge required for learning the new topic or concept. The learning/teaching phase is broadly described as three phases,

- Introductory/ Preparatory phase
- Developmental/ Presentation phase
- Consolidation and Evaluation phase

Introductory/ Preparatory Phase

The teacher prepares or makes the learners ready for acquiring new knowledge in this phase. The new topic/ concept is introduced in an interesting manner. Teacher creates problematic or puzzling situation so as to make a felt need for acquiring new knowledge in this stage.

Developmental/ Presentation Phase

In this phase, the concept or subject matter is presented or the learners acquires the new knowledge through individual or group activities. Learning activities designed are described here. Introduction to the activities, indicators for doing the acuities are mentioned here. Each activities are evaluated after finishing the task. In short this phase includes presentation of the content, presentation of appropriate activities, student responses and evaluation of the activities.

Consolidation/Evaluation Phase

Student reflection and consolidation are incorporated after each activities as well as at the end of the lesson plan. Learners are being evaluated in between the activities and at the end of the lesson with suitable evaluation techniques. Follow up activities are provided as extended activities to be carried out for affirming the knowledge and skills acquired.

The investigator prepared 12 lesson transcripts of 40 minutes duration. A copy of one of the lesson transcripts that was used in the present study for conventional method of teaching geometry in Malayalam and its English version are presented in Appendices III and IV respectively.

4. Standard Progressive Matrices Test (Raven, 1958)

This test was employed to measure the Non-verbal Intelligence level of students of the experimental and control groups. This test was constructed by Raven (1958). The test was used for finding the subjects' ability to recognize a logical relationship among the presented non-verbal materials.

The test contains five sub-tests (A, B, C, D and E) of 12 items each. Each item consists of a series of diagrammatic/geometrical puzzles showing serial changes in two dimensions. A part of the diagrammatic/geometrical series puzzle is missing in each item. The subject should find the missing element from the options given. All of the options may fit the missing part, but only one logically belongs to it. Six or eight options are given for each item.

The test appeals for identification of abstract relationships. The testee must identify relationships as he/she see the patterns horizontally and vertically but need not see them both at once.

In each set, the first problem is nearly self-evident. Subsequently the problems become more and more difficult. The five sets provide five occasions to grasp the method of thought required to solve problems and five progressive assessment of person's capacity for intellectual activity. Thus it is obvious that this test is meant to assess the chief cognitive processes.

The time to complete the test was 40 minutes. Instructions regarding to the test were given to the students after establishing a rapport with them. Then the question booklets and answer sheets were distributed. It was made sure that those who attended the test understand what they have to do, and clarifications related to the test were made in between. Uniformity was maintained in administrations and instructions.

The total number of items answered correctly is the total score of the test. Since the test has a total of 60 items (12 items from each of the five sub-tests), the maximum total score of the test is 60.

Validity of the test has been estimated by different ways. When Stanford Binet test was used as criterion, correlation coefficient of the test varied from 0.50 to 0.86. The reliability coefficient of the test varied from 0.80 to 0.90 as reported by Raven.

A copy of response sheet of Standard Progressive Matrices Test is given in Appendix VIII.

Experimentation Procedure

Having detailed discussion over the tools and Virtual Leaning Environment using Geogebra developed by the investigator along with the research supervisor, the investigator took the steps towards the experimentation phase of the study. The investigator selected the most suitable school for experimentation process of the study. Permission and cooperation of the school authorities and teachers of Mathematics ensured at the outset. Preliminary discussion about the study has been carried out with them.

The investigator began the experimentation process by choosing two intact classes of IX standard students of the school. One group was selected as the experimental group and the other as the control group. As the initial step, pretest on Problem solving ability in Geometry has been administered on both experimental and control groups. The investigator had given proper instruction regarding the procedure for writing the answers to both experimental and control groups in advance and ensured the rules and regulations of the test is being kept. After the pre-test on Problem solving ability, a test on Standard Progressive Matrices prepared by JC Raven was administered to test the Nonverbal intelligence of the subjects.

At the next phase, the experimental group was treated with the instructional strategy Virtual learning Environment using Geogebra in geometry prepared based on the chapter 'Prisms' in the Mathematics text book of 9th standard following SCERT curriculum prevailing in Kerala state. At the same time the control group was treated with conventional instructional strategy on the same content area. The medium of instruction followed in the instructional strategy, Virtual Learning Environment and in the Conventional Instructional Strategy was Malayalam.

After completion of the intervention with Virtual Learning Environment using Geogebra in geometry in experimental group and conventional instructional strategy in control group, a post test on Problem solving ability has been carried out on both groups. All the test were scored accordingly and subjected to statistical analysis.

Scoring Procedures

As part of the study data were collected mainly through two tools Viz. Problem Solving ability Test and Non-verbal intelligence test. Raven's Standard Progressive Matrices. The collected data were properly tabulated and scoring was done.

The Test for assessing Problem Solving Ability in geometry was scored using the marking scheme prepared. The test contained 15 items and each have 4 sub questions viz. A, B, C and D. The sub questions were prepared so as to use the capacities of each components of problem solving ability. The students were expected to write the answers following sequential steps. The maximum marks for the Problem Solving Ability test was 60. Score for the such questions in each item was 1 and the total was 4.

The Nonverbal Intelligence Test (Standard Progressive Matrices) was administered in the initial stage of the study and was scored as per the scoring key and guidelines given in the manual for Raven's Progressive Matrices (1958).

The tabulated and consolidated data then subjected for statistical analysis.

Statistical Techniques Employed

Statistical treatment of data is in important stage in quantitative research as it is inevitable for further analysis and to yield inferences. The score obtained from 90 IXth standard students were subjected to statistical analysis. In order to explore the nature of distribution of variables important statistical constants such as Mean, Median, Mode, Standard Deviation, Skewness and Kurtosis were worked out for total sample and relevant sub samples. The various statistical techniques used for analysis of quantitative data are following.

Test of Significance of Difference between Means

The statistical technique, the test of significance of difference between different categories is used to check whether of there exists any significant difference among total sample based on relevant sub sample .The mean difference was computed by using the formula.

$$t = \frac{M_1 - M_2}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}}$$

Where,

M_1= Mean for the first group

M_2 = Mean for the second group

σ_1 = Standard deviation for the first group

σ_2 = Standard deviation for the second group

N_1 = Size of the sample for the first group

N_2 = Size of the sample for the second group. (Best & Kahn, 2010)

If the obtained ‘t’ value was greater than 1.96, it was treated as significant at 0.05 level and if it was greater than 2.58 it was treated as significant at 0.01 level.

Analysis of Covariance (ANCOVA)

The design adopted for the study was pretest posttest non-equivalent group design. In order to statistically remove the differences in initial status of experimental and control groups ANCOVA was used. Analysis of covariance uses the principle of partial correlation with analysis of variance. It is used to determine whether there are any significant differences between two or more independent (unrelated) groups on a dependent variable. ANCOVA looks for differences in adjusted means (i.e., adjusted for the covariate). ANCOVA serves the purpose of statistically removing the effect of extraneous variables from the dependent variables (Ferguson, 1986). ANCOVA is an important method of analyzing the experiments carried under condition that otherwise would be unacceptable.

ANCOVA can only be appropriate to use if data satisfies following assumption.

- Dependent variable and covariate variable(s) should be measured on a continuous scale.
- Independent variable should consist of two or more categorical, independent groups
- Independence of observations
- There should be no significant outliers
- Residuals should be approximately normally distributed for each category of the independent variable.
- There needs to be homogeneity of variances.
- The covariate should be linearly related to the dependent variable at each level of the independent variable.
- There needs to be homoscedasticity
- There needs to be homogeneity of regression slopes, which means that there is no interaction between the covariate and the independent variable

Bonferroni's Test of Post-hoc Comparison

In order to compare the adjusted mean scores of Problem Solving Ability in Geometry of experimental and control groups, ANCOVA was followed by Bonferroni's test of post-hoc comparison.

Effect Size

Effect size is a measure of magnitude of differences between two groups. Effect size helps to quantify relative effectiveness of a particular intervention (Coe, 2002). So the investigator calculated effect size for independent sample *t* test in terms of Cohen's *d* and for ANCOVA in terms of Partial eta squared (η_p^2).

To interpret the effect size, Cohen's *d,* Cohen (1988) proposed the criteria: 0.2 indicates small effect, 0.5 indicates medium effect and 0.8 indicates large effect.

The investigator used the application softwares, M.S Excel and SPSS wherever applicable to analyze the data employing the above mentioned statistical techniques.

Chapter **4**

ANALYSIS AND INTERPRETATION OF DATA

- ***Preliminary Statistical Analysis of the Variables***
- ***Mean Difference Analysis***
- ***Analysis of Covariance of the Dependent Variables***

ANALYSIS AND INTERPRETATION OF DATA

The present study was aimed to to find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School students. The design of the study was quasi experimental with pretest posttest non-equivalent groups design. The experimental group was taught through Virtual Learning Environment and the control group was taught through Existing Method of Teaching.

The data from the experiment were analyzed using the test of significance of difference between means followed by the calculation of Analysis of Covariance by considering Non Verbal Intelligence as covariate.

The analysis of data from the experiment consists of the following major headings:

- Preliminary statistical analysis of the variables
  - Pretest scores of the variables for the experimental group
  - Pretest scores of the variables for the control group
  - Posttest scores of the variables for the experimental group
  - Posttest scores of the variables for the control group
  - Gain scores of the Variables for the Experimental Group
  - Gain scores of the Variables for the Control Group
- Mean Difference Analysis
  - Comparison of mean pretest and posttest scores of Problem Solving Ability in Geometry of experimental group
  - Comparison of mean posttest scores of Problem Solving Ability in Geometry of experimental and control groups
  - Comparison of mean gain scores of Problem Solving Ability in Geometry of experimental and control groups

- Analysis of Covariance of the dependent variables
  - Comparison of the adjusted mean gain scores of Problem Solving Ability in Geometry of experimental and control group by considering Non - verbal Intelligence as covariate.

General Objectives

1. To develop a Virtual Learning Environment using Geogebra on geometry for secondary school students.
2. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School students

Specific Objectives

1. To find out the effect of Virtual Learning Environment using Geogebra on first component of Problem Solving Ability (Understanding the Problem) in Geometry of Secondary School students for the total group and subgroups based on gender.
2. To find out the effect of Virtual Learning Environment using Geogebra on second component of Problem Solving Ability(Mapping the Problem) in Geometry of Secondary School Students for the total group and subgroups based on gender.
3. To find out the effect of Virtual Learning Environment using Geogebra on third component of Problem Solving Ability (Identifying relationships) in Geometry of Secondary School Students for the total group and subgroups based on gender.
4. To find out the effect of Virtual Learning Environment using Geogebra on fourth component of Problem Solving Ability (Finding the solution to the problem) in Geometry of Secondary School Students for the total group and subgroups based on gender.

5. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability (Total) in Geometry of Secondary School Students for the total group and subgroups based on gender.
6. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on first component of Problem Solving Ability (Understanding the Problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
7. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on second component of Problem Solving Ability (Mapping the Problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
8. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on third component of Problem Solving Ability (Identifying relationships) in geometry of Secondary School Students for the total group and subgroups based on gender.
9. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on fourth component of Problem Solving Ability (Finding solution to the problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
10. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on Problem Solving Ability (Total) in Geometry of Secondary School Students for the total group and subgroups based on gender.

Hypotheses of the Study

1. Virtual Learning Environment using Geogebra has significant effect on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender
2. Virtual Learning Environment using Geogebra has significant effect on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender
3. Virtual Learning Environment using Geogebra has significant effect on ability to Identify Relationships in the problem in Geometry of Secondary School Students for the total group and subgroups based on gender
4. Virtual Learning Environment using Geogebra has significant effect on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender
5. Virtual Learning Environment using Geogebra has significant effect on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender
6. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
7. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Map the Problem in Geometry of Secondary School Students for the total group and

subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

8. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Identify Relationships in the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
9. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.
10. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Analysis of Data

Statistical Constants of the Variables

Preliminary analysis was done to identify important statistical properties of the variables. Mean, Median, Mode, Standard Deviation, Skewness and Kurtosis of the pretest scores of covariate Non-verbal Intelligence and those of the pretest and post test scores of the dependent variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) was calculated separately for experimental and control groups for Total sample, subsample Boys and subsample Girls.

The Non-verbal Intelligence of secondary school students belonging to experimental and control groups was measured using Standard Progressive Matrices Test (Raven, 1958). The maximum and minimum possible scores of Standard Progressive Matrices Test are 60 and zero respectively.

To collect data on Problem solving ability in geometry, Problem Solving Ability Test in Geometry (Praveen & Rishad, 2019) was administered. The Problem Solving Ability Test in Geometry has four components, namely, Understanding the problem, Mapping the problem, Identifying relationships and Finding the solution. For each question, maximum and minimum possible scores are 4 and zero respectively. The total score of the test is sum of the scores obtained for each question. The maximum and minimum possible scores for The Problem Solving Ability Test in Geometry are 60 and zero respectively.

Normal P-P plots of the pretest scores of the variables were also drawn to examine the normality of pretest scores of experimental and control groups.

Pretest Scores of the Variables for the Experimental Group

The mean, median, mode, standard deviation, skewness and kurtosis of the pretest scores of the variables Non-verbal Intelligence, Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental group for Total sample, subsample Boys and subsample Girls are presented in Table 4, Table 5 and Table 6 respectively.

Table 4

Statistical Constants of the Pretest Scores of the Variables for the Experimental Group – Total sample

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Non Verbal Intelligence		42.95	44.00	38.00	7.17	-0.93	1.55
Problem Solving Ability	Understanding the problem	6.18	6.00	7.00	1.73	0.02	-0.80
	Mapping the problem	5.52	6.00	6.00	2.05	0.03	-0.69
	Identifying relationships	4.36	5.00	5.00	2.31	-0.23	-0.66
	Finding the solution	4.75	4.00	4.00	1.50	0.32	-0.67
	Total	20.82	22.00	26.00	6.27	-0.37	-0.73

Table 5

Statistical Constants of the Pretest Scores of the Variables for the Experimental Group – Subsample Boys

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Non Verbal Intelligence		42.06	41.00	38.00	6.86	-0.50	-0.24
Problem Solving Ability	Understanding the problem	5.11	5.00	5.00	1.57	0.93	0.76
	Mapping the problem	4.33	4.00	6.00	1.75	0.31	-0.73
	Identifying relationships	2.56	2.50	2.00	1.58	-0.06	-1.03
	Finding the solution	3.50	4.00	4.00	0.79	-0.41	-0.07
	Total	15.50	14.50	14.00	4.91	0.50	-0.41

Table 6

Statistical Constants of the Pretest Scores of the Variables for the Experimental Group – Subsample Girls

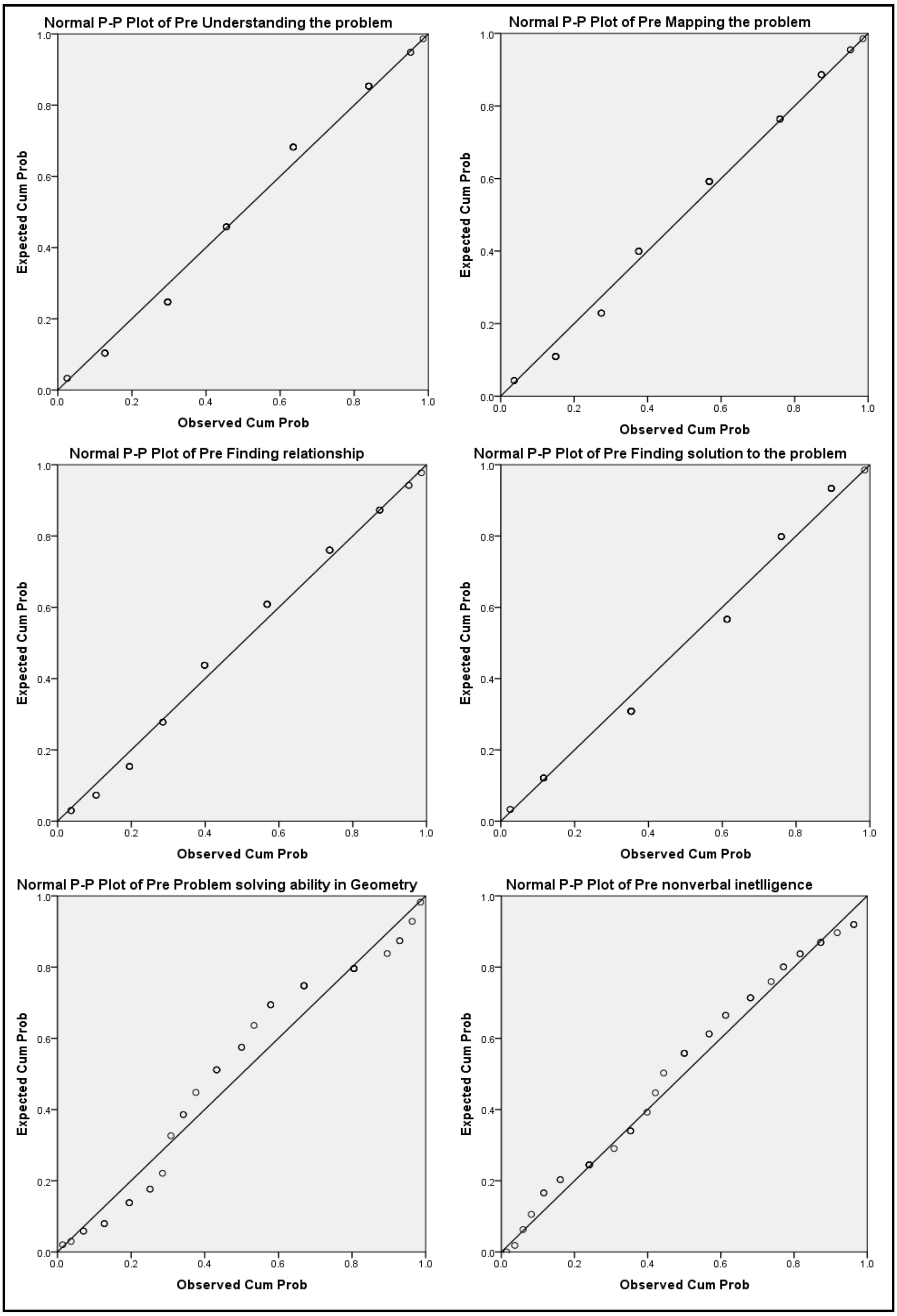
Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Non Verbal Intelligence		43.58	45.50	47	7.44	-1.45	3.39
Problem Solving Ability	Understanding the problem	6.92	7.00	8.00	1.44	-0.29	0.10
	Mapping the problem	6.35	6.00	6.00	1.85	-0.19	-0.27
	Identifying relationships	5.62	6.00	6.00	1.88	-1.04	2.33
	Finding the solution	5.62	5.50	5.00	1.24	0.13	-1.21
	Total	24.50	25.00	26.00	4.08	-0.80	3.21

Table 4, Table 5 and Table 6 show that the values of mean, median and mode of the pretest scores of the variables for Total sample, subsample Boys and subsample Girls in the experimental group are almost similar. The standard deviations of the variables show that the scores are somewhat dispersed from the central value. The values of skewness and kurtosis of Non-verbal Intelligence, Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls indicate that the distributions are approximately normal.

The P-P plots of the pretest scores of the variables of the experimental group for Total sample are presented as Figure 18 which shows only slight deviations of observed cumulative probability from diagonals in each of the P-P plots. This implies that all distributions are approximately normal.

Figure 18

The P-P Plots of the Pretest Scores of the Variables of the Experimental Group for Total Sample



Pretest Scores of the Variables for the Control Group

The mean, median, mode, standard deviation, skewness and kurtosis of the pretest scores of the variables Non-verbal Intelligence, Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of control group for Total sample, subsample Boys and subsample Girls are presented in Table 7, Table 8 and Table 9 respectively.

Table 7

Statistical Constants of the Pretest Scores of the Variables for the Control Group - Total Sample

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Non Verbal Intelligence		42.89	43.50	43.00	7.26	-1.5	3.02
Problem Solving Ability	Understanding the problem	4.24	4.00	4.00	2.42	0.48	0.01
	Mapping the problem	6.70	7.00	7.00	2.40	0.24	-0.06
	Identifying relationships	4.41	4.00	4.00	1.85	0.53	-0.07
	Finding the solution	3.70	4.00	2.00	1.84	0.47	-0.41
	Total	19.04	17.00	16.00	7.11	0.73	-0.27

Table 8

Statistical Constants of the Pretest Scores of the Variables for the Control Group – Subsample Boys

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Non Verbal Intelligence		43.87	44.00	43.00	6.46	-1.47	4.07
Problem Solving Ability	Understanding the problem	4.42	4.00	4.00	2.50	0.32	-0.01
	Mapping the problem	6.74	7.00	7.00	2.38	-0.23	-0.64
	Identifying relationships	4.45	4.00	4.00	2.01	0.64	-0.35
	Finding the solution	3.94	4.00	2.00	2.01	0.33	-0.76
	Total	19.55	17.00	10.00	7.65	0.56	-0.55

Table 9

Statistical Constants of the Pretest Scores of the Variables for the Control Group – Subsample Girls

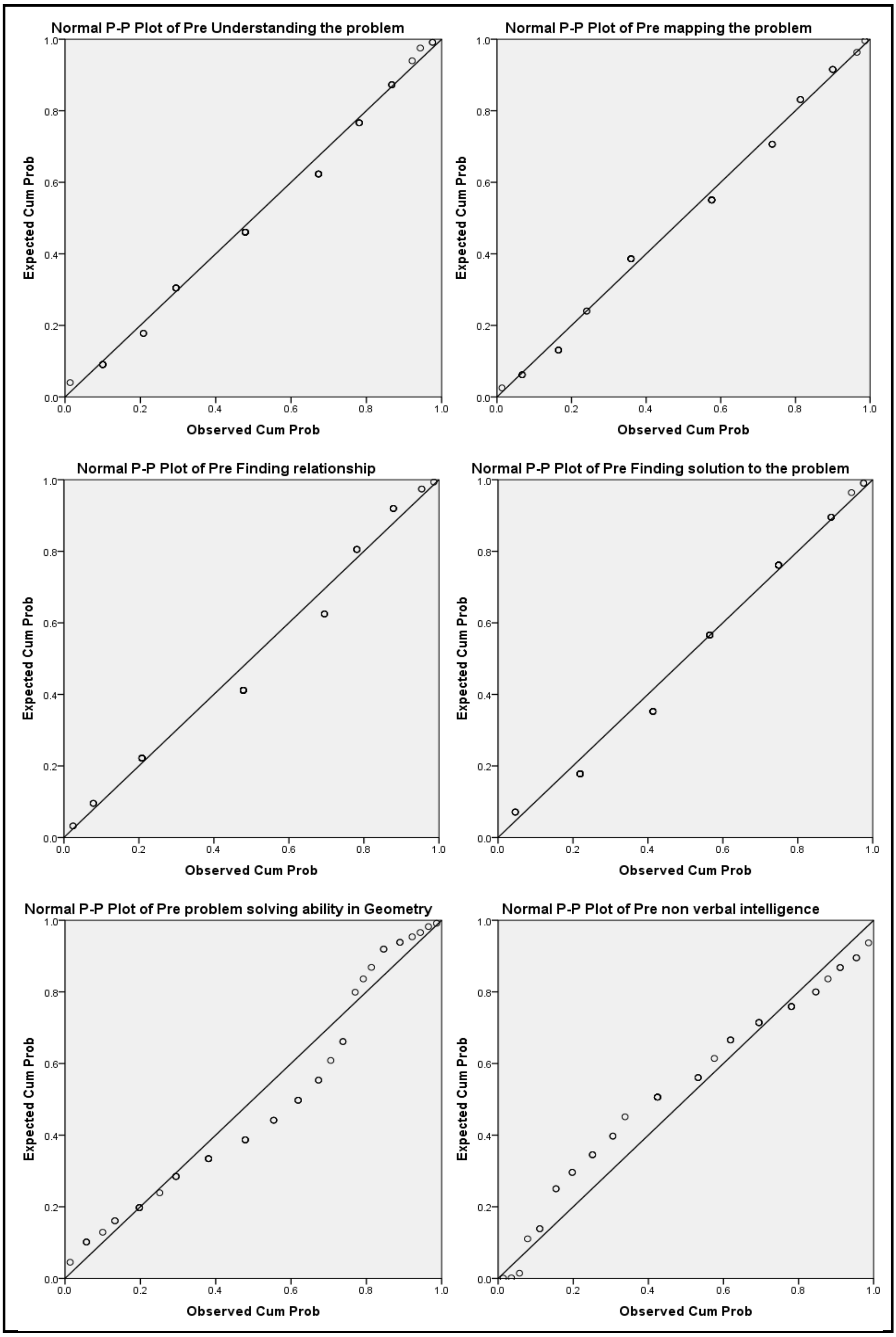
Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Non Verbal Intelligence		40.87	43.00	43.00	8.58	-1.40	2.13
Problem Solving Ability	Understanding the problem	3.87	4.00	3.00	2.30	0.92	0.96
	Mapping the problem	6.60	6.00	6.00	2.53	1.16	1.89
	Identifying relationships	4.33	4.00	4.00	1.50	-0.22	0.70
	Finding the solution	3.20	3.00	2.00	1.32	0.01	-1.35
	Total	18.00	17.00	13.00	5.94	1.22	1.07

Table 7, Table 8 and Table 9 show that the values of mean, median and mode of the pretest scores of the variables for Total sample, subsample Boys and subsample Girls in the control group are almost similar. The standard deviations of the variables show that the scores are somewhat dispersed from the central value. The values of skewness and kurtosis of Non-verbal Intelligence, Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls indicate that the distributions are approximately normal.

The P-P plots of the pretest scores of the variables of the control group for Total sample are presented as Figure 19 which shows only slight deviations of observed cumulative probability from diagonals in each of the P-P plots. This implies that all distributions are approximately normal.

Figure 19

The P-P Plots of the Pretest Scores of the Variables of the Control Group for Total Sample



Posttest Scores of the Variables for the Experimental Group

The mean, median, mode, standard deviation, skewness and kurtosis of the posttest scores of the variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental group for Total sample, subsample Boys and subsample Girls are presented in Table 10, Table 11 and Table 12 respectively.

Table 10

Statistical Constants of the Posttest Scores of the Variables for the Experimental Group – Total Sample

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	11.91	12.00	12.00	2.05	-1.43	2.66
	Mapping the problem	12.64	13.00	13.00	1.86	-1.7	5.53
	Identifying relationships	9.41	10.00	10.00	2.56	-0.99	1.14
	Finding the solution	8.18	8.50	10.00	2.29	-0.47	0.92
Total		42.14	44.00	45.00	7.8	-1.45	3.38

Table 11

Statistical Constants of the Posttest Scores of the Variables for the Experimental Group – Subsample Boys

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	11.56	12.00	12.00	2.38	-1.49	2.91
	Mapping the problem	12.89	13.50	15.00	2.45	-2.08	5.78
	Identifying relationships	8.89	9.00	9.00	2.63	-1.06	2.62
	Finding the solution	8.00	8.00	7.00	2.57	-0.19	2.03
Total		41.33	43.00	47.00	9.29	-1.52	4.21

Table 12

Statistical Constants of the Posttest Scores of the Variables for the Experimental Group – Subsample Girls

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	12.15	12.00	12.00	1.78	-1.17	1.42
	Mapping the problem	12.46	13.00	13.00	1.33	-0.73	0.75
	Identifying relationships	9.77	10.50	12.00	2.49	-1.03	0.57
	Finding the solution	8.31	9.00	10.00	2.11	-0.74	-0.03
Total		42.69	45.00	45.00	6.72	-1.14	0.78

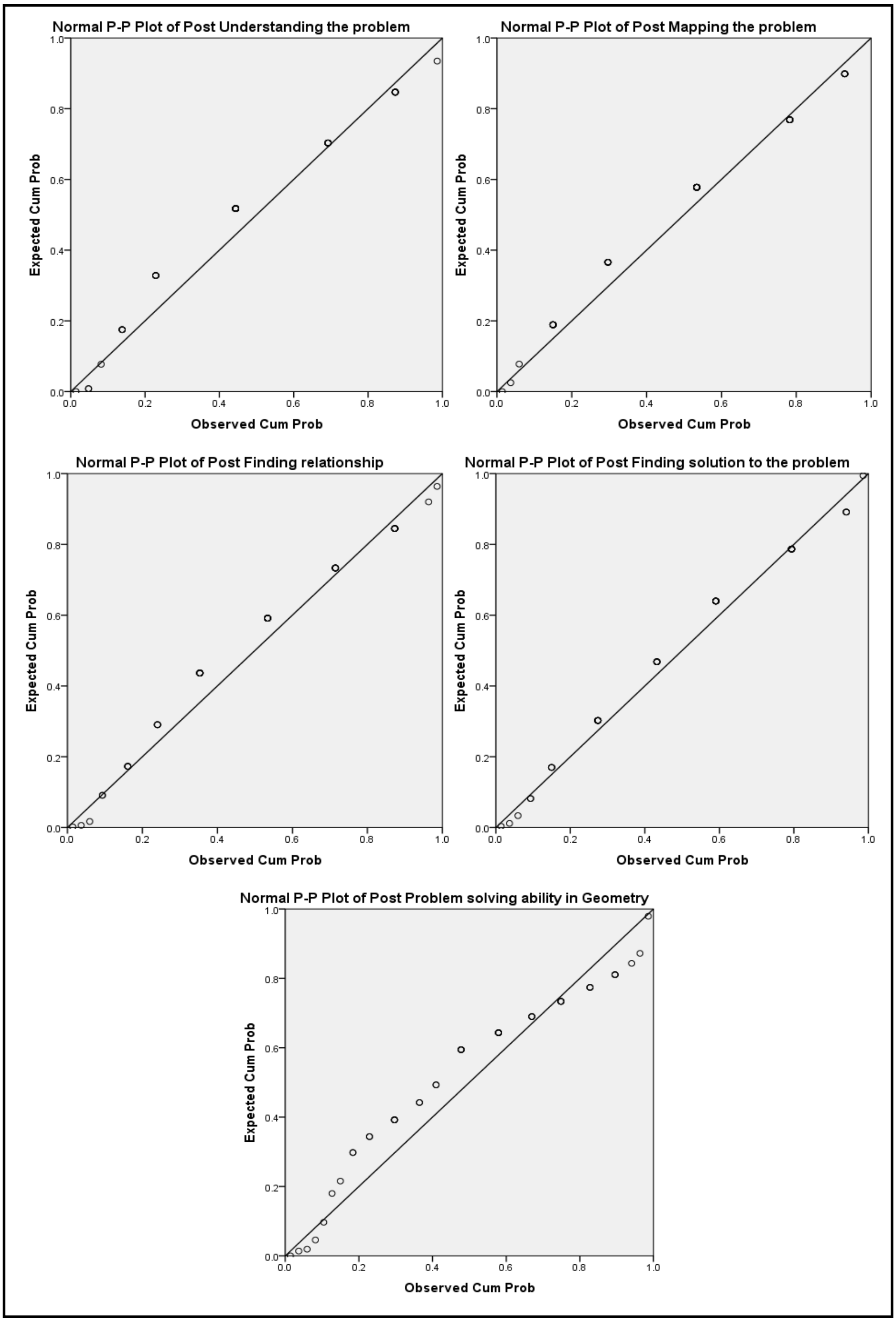
Table 10, Table 11 and Table 12 show that the values of mean, median and mode of the posttest scores of the variables for Total sample, subsample Boys and subsample Girls in the experimental group are almost similar. The standard deviations of the variables show that the scores are somewhat dispersed from the central value.

The values of skewness and kurtosis of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls indicate that the distributions are approximately normal.

The P-P plots of the posttest scores of the variables of the experimental group for Total sample are presented as Figure 20 which shows only slight deviations of observed cumulative probability from diagonals in each of the P-P plots. This implies that all distributions are approximately normal.

Figure 20

The P-P Plots of the Posttest Scores of the Variables of the Experimental Group for Total Sample



Posttest Scores of the Variables for the Control Group

The mean, median, mode, standard deviation, skewness and kurtosis of the posttest scores of the variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of control group for Total sample, subsample Boys and subsample Girls are presented in Table 13, Table 14 and Table 15 respectively.

Table 13

Statistical Constants of the Posttest Scores of the Variables for the Control Group – Total Sample

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	5.28	5.00	4.00	2.48	0.36	-0.94
	Mapping the problem	7.67	8.00	8.00	2.25	0.31	-0.51
	Identifying relationships	5.20	5.00	5.00	2.62	0.12	-0.46
	Finding the solution	4.24	4.00	2.00	2.02	0.65	0.36
	Total	22.39	21.00	16.00	8.10	0.62	-0.17

Table 14

Statistical Constants of the Posttest Scores of the Variables for the Control Group – Subsample Boys

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	5.65	5.00	4.00	2.48	0.14	-0.88
	Mapping the problem	7.55	8.00	5.00	2.45	0.18	-1.16
	Identifying relationships	5.16	5.00	2.00	3.04	0.12	-0.98
	Finding the solution	4.74	5.00	4.00	2.11	0.45	0.08
	Total	23.10	22.00	22.00	8.99	0.39	-0.54

Table 15

Statistical Constants of the Posttest Scores of the Variables for the Control Group – Subsample Girls

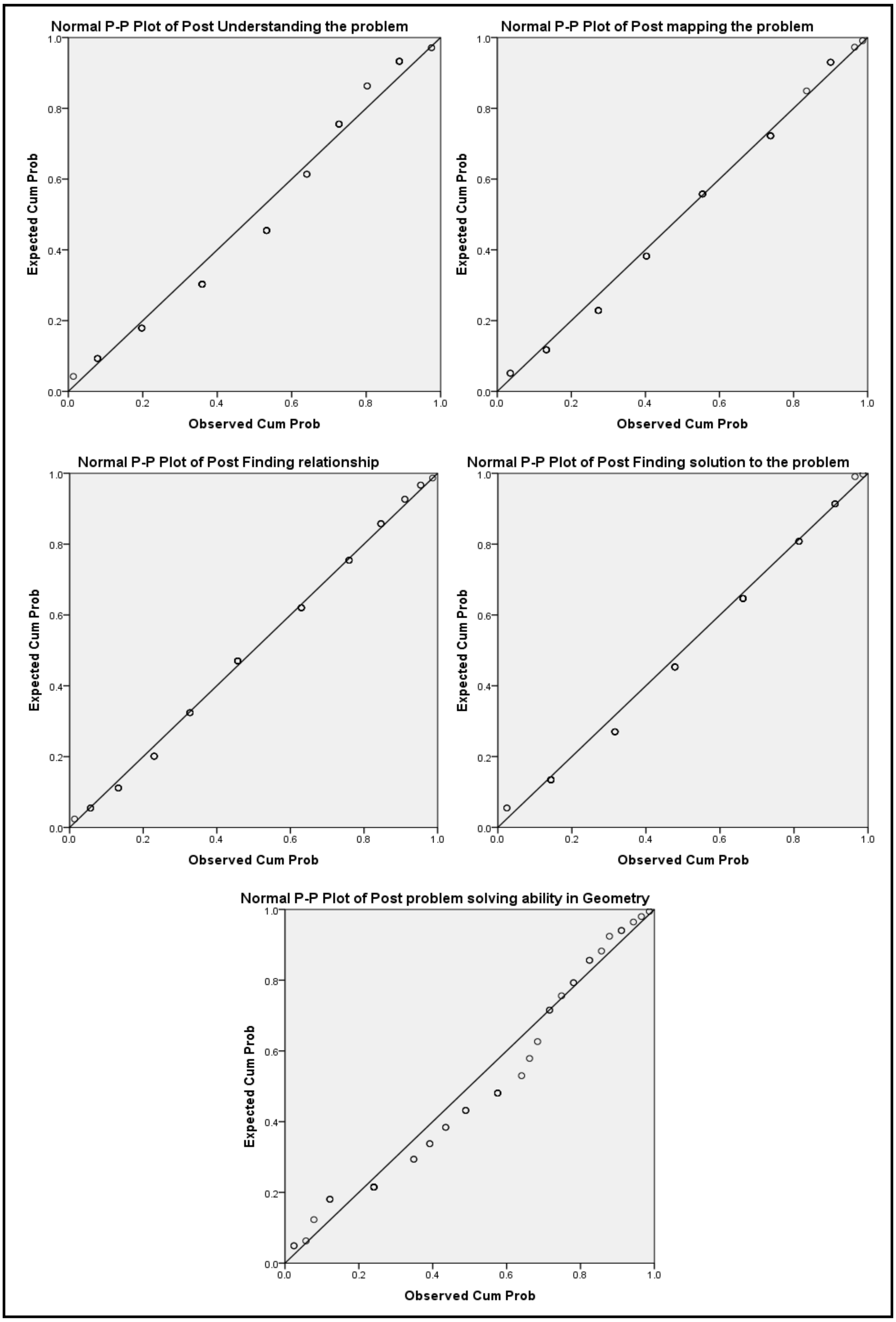
Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	4.53	4.00	2.00	2.39	0.97	-0.11
	Mapping the problem	7.93	8.00	6.00	1.83	1.40	3.28
	Identifying relationships	5.27	5.00	5.00	1.49	0.38	0.07
	Finding the solution	3.20	3.00	2.00	1.37	0.16	-1.40
	Total	20.93	20.00	16.00	5.85	1.29	1.05

Table 13, Table 14 and Table 15 show that the values of mean, median and mode of the posttest scores of the variables for Total sample, subsample Boys and subsample Girls in the control group are almost similar. The standard deviations of the variables show that the scores are somewhat dispersed from the central value. The values of skewness and kurtosis of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls indicate that the distributions are approximately normal.

The P-P plots of the posttest scores of the variables of the control group for Total sample are presented as Figure 21 which shows only slight deviations of observed cumulative probability from diagonals in each of the P-P plots. This implies that all distributions are approximately normal.

Figure 21

The P-P Plots of the Posttest Scores of the Variables of the Control Group for Total Sample



Gain Scores of the Variables for the Experimental Group

The mean, median, mode, standard deviation, skewness and kurtosis of the gain scores of the variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental group for Total sample, subsample Boys and subsample Girls are presented in Table 16, Table 17 and Table 18 respectively.

Table 16

Statistical Constants of the Gain Scores of the Variables for the Experimental Group – Total Sample

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	5.73	6.00	7.00	2.17	-0.47	-0.62
	Mapping the problem	7.11	7.00	6.00	2.96	-0.43	-0.03
	Identifying relationships	5.05	5.00	5.00	2.46	-0.51	0.28
	Finding the solution	3.43	4.00	4.00	2.39	-0.29	0.92
	Total	21.32	21.00	21.00	8.45	-0.52	-0.22

Table 17

Statistical Constants of the Gain Scores of the Variables for the Experimental Group – Subsample Boys

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	6.44	7.00	7.00	2.09	-1.58	2.29
	Mapping the problem	8.56	9.50	10.00	3.11	-1.30	2.04
	Identifying relationships	6.33	6.50	6.00	2.45	-1.08	1.69
	Finding the solution	4.50	5.00	5.00	2.57	-0.61	1.82
	Total	25.83	27.00	27.00	8.89	-1.71	2.95

Table 18

Statistical Constants of the Gain Scores of the Variables for the Experimental Group – Subsample Girls

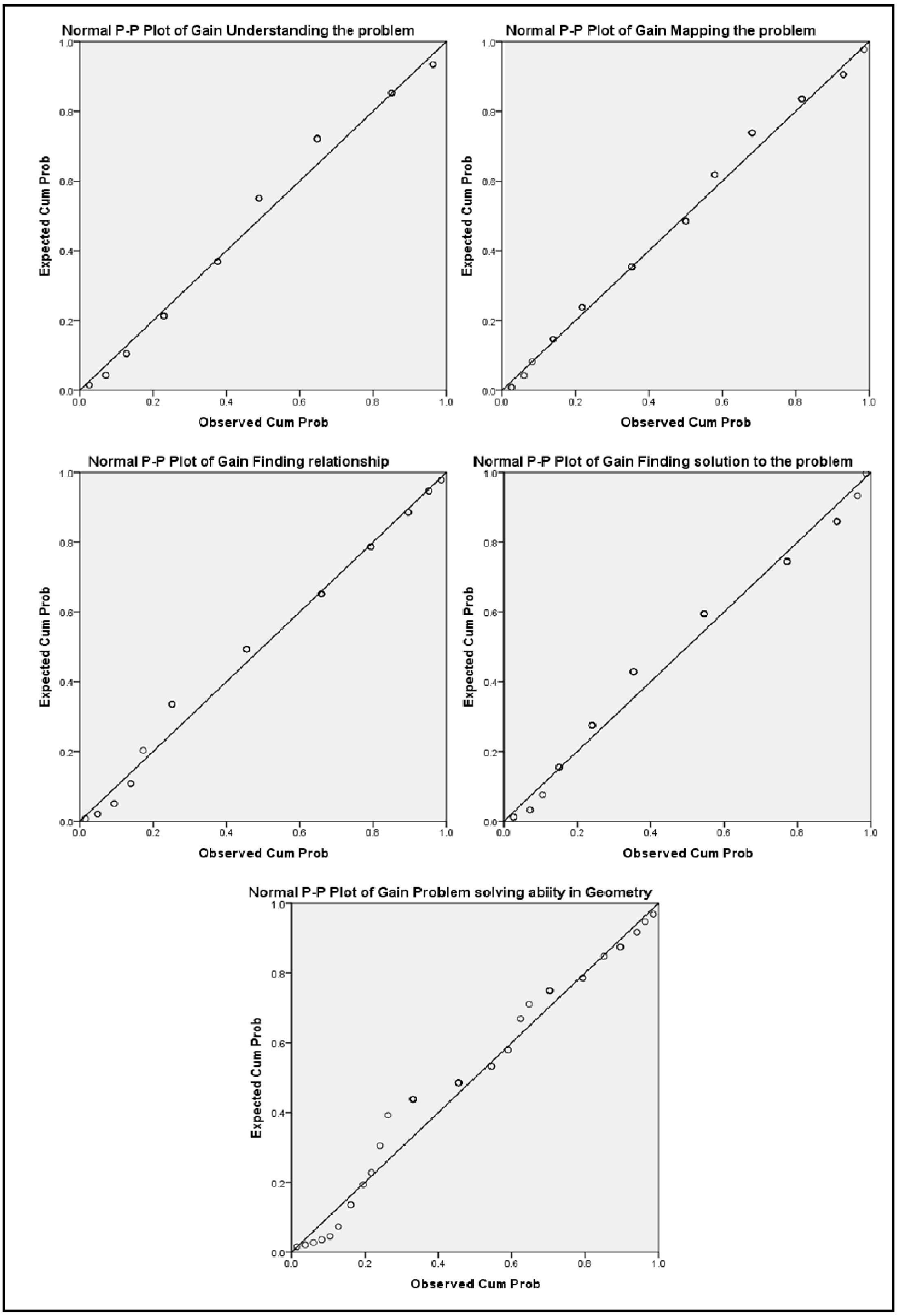
Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	5.23	5.00	4.00	2.12	0.11	-0.67
	Mapping the problem	6.12	6.00	6.00	2.44	-0.49	0.28
	Identifying relationships	4.15	5.00	5.00	2.07	-0.95	0.59
	Finding the solution	2.69	3.00	4.00	1.98	-0.92	0.77
Total		18.19	20.00	20.00	6.65	-0.52	-0.07

Table 16, Table 17 and Table 18 reveal that the values of mean, median and mode of the gain scores of the variables for Total sample, subsample Boys and subsample Girls in the experimental group are almost similar. The standard deviations of the variables show that the scores are somewhat dispersed from the central value. The values of skewness and kurtosis of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls indicate that the distributions are approximately normal.

The P-P plots of the gain scores of the variables of the experimental group for Total sample are presented as Figure 22 which shows only slight deviations of observed cumulative probability from diagonals in each of the P-P plots. This implies that all distributions are approximately normal.

Figure 22

The P-P Plots of the Gain Scores of the Variables of the Experimental Group for Total Sample



Gain Scores of the Variables for the Control Group

The mean, median, mode, standard deviation, skewness and kurtosis of the gain scores of the variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of control group for Total sample, subsample Boys and subsample Girls are presented in Table 19, Table 20 and Table 21 respectively.

Table 19

Statistical Constants of the Gain Scores of the Variables for the Control Group – Total Sample

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	1.04	1.00	1.00	1.96	0.20	-0.39
	Mapping the problem	0.98	1.00	2.00	1.77	-0.17	0.31
	Identifying relationships	0.78	1.00	2.00	1.99	-0.19	-0.18
	Finding the solution	0.54	1.00	2.00	1.83	-0.23	-0.03
Total		3.35	3.00	3.00	4.25	0.11	0.67

Table 20

Statistical Constants of the Gain Scores of the Variables for the Control Group - Subsample Boys

Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	1.23	1	1	1.21	0.18	-0.60
	Mapping the problem	0.81	1.00	1	1.74	-0.37	0.80
	Identifying relationships	0.71	1.00	1	2.25	-0.09	-0.46
	Finding the solution	0.81	1.00	2	1.83	-0.07	-0.61
Total		3.55	3.00	5	4.99	0.01	0.09

Table 21

Statistical Constants of the Gain Scores of the Variables for the Control Group – Subsample Girls

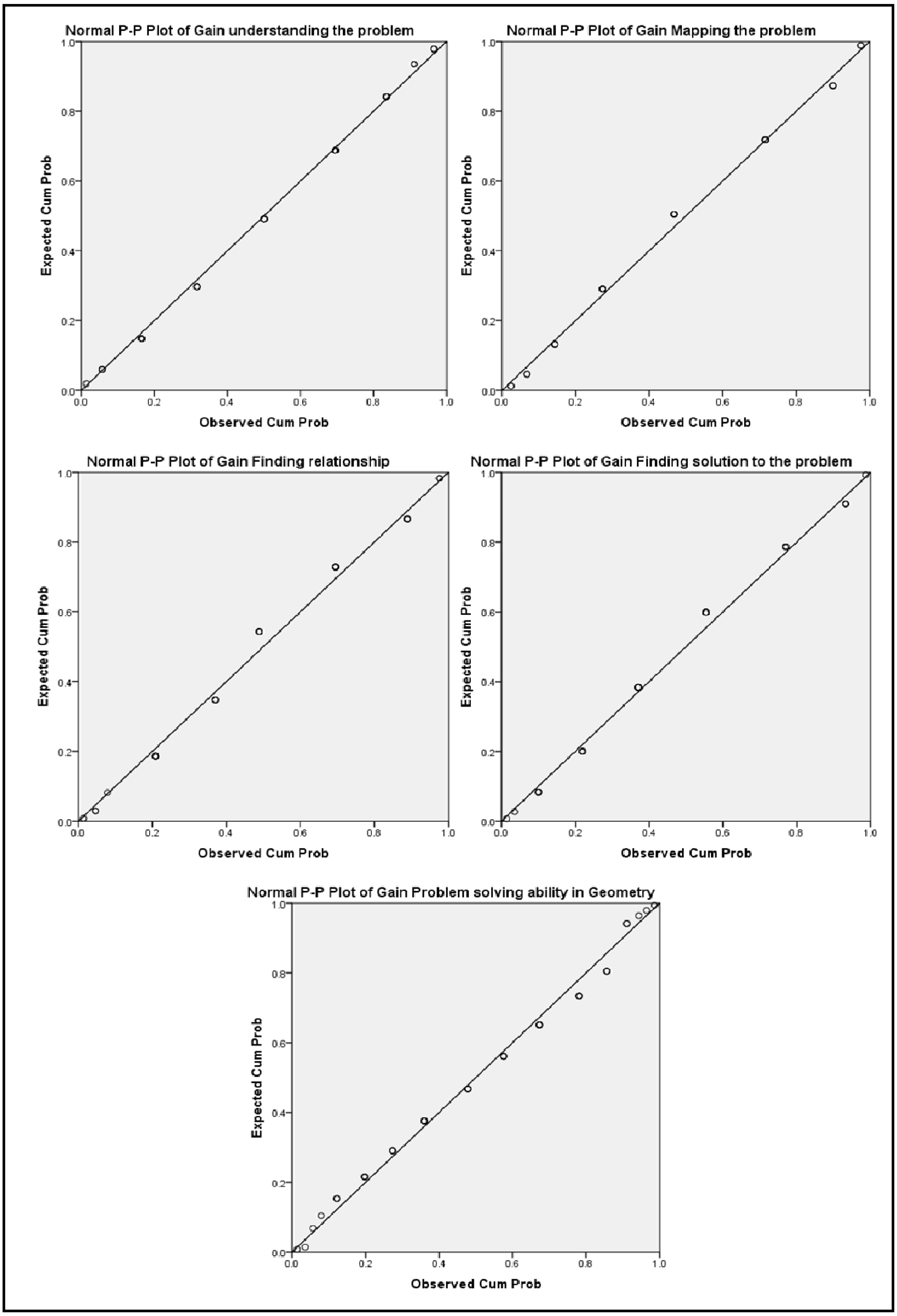
Variable		Mean	Median	Mode	S.D.	Skewness	Kurtosis
Problem Solving Ability	Understanding the problem	0.67	1.00	1.00	1.59	-0.35	-0.62
	Mapping the problem	1.33	2.00	1.00	1.84	0.15	-0.63
	Identifying relationships	0.93	1.00	2.00	1.38	-0.42	-1.32
	Finding the solution	0.00	0.00	0.00	1.77	-0.80	1.13
Total		2.93	3.00	3.00	2.52	-0.01	-0.63

Table 19, Table 20 and Table 21 reveal that the values of mean, median and mode of the gain scores of the variables for Total sample, subsample Boys and subsample Girls in the control group are almost similar. The standard deviations of the variables show that the scores are somewhat dispersed from the central value. The values of skewness and kurtosis of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls indicate that the distributions are approximately normal.

The P-P plots of the gain scores of the variables of the control group for Total sample are presented as Figure 23 which shows only slight deviations of observed cumulative probability from diagonals in each of the P-P plots. This implies that all distributions are approximately normal.

Figure 23

The P-P Plots of the Gain Scores of the Variables of the Control Group for Total Sample



Discussion

The important statistical constants of pretest, posttest and gain scores of the variables for experimental and control groups and normal P-P plots show that the scores are normally distributed. Hence parametric testing can be performed on the data.

Mean Difference Analysis

Difference in mean pretest and posttest scores of the dependent variables of the experimental group, difference in mean posttest scores of the dependent variables between the experimental and control groups and difference in mean gain scores of the dependent variables between experimental and control groups were investigated before controlling the effects of the covariates. The comparisons were done using mean difference analysis.

Comparison of Mean Pretest and Posttest Scores of Problem Solving Ability in Geometry of the Experimental Group

To test the effect of Virtual Learning Environment using Geogebra in improving Problem solving ability in geometry, the mean scores of the students belonging to experimental group before and after intervention were compared for Total sample, subsample Boys and subsample Girls.

Comparison of Mean Pretest and Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total)) of Experimental Group for Total Sample

To compare the mean performance of total sample in experimental group on pretest and posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total), the means and standard deviations of pretest and posttest scores were subjected paired t test. The data and results of the test are given in Table 22.

Table 22

Results of Test of Significance of Difference in Mean Pretest Scores and Mean Posttest Scores of Problem Solving Ability in Geometry of Experimental Group - Total Sampleh

Variable		N	Experimental Group				r	t
			Posttest		Pretest			
			M_2	SD_2	M_1	SD_1		
Problem solving ability in geometry	Understanding the problem	44	11.91	2.04	6.18	1.73	.35	17.50**
	Mapping the problem	44	12.64	1.86	5.52	2.05	.14	15.95**
	Identifying relationships	44	9.41	2.55	4.36	2.31	.49	13.61**
	Finding the solution	44	8.18	2.29	4.75	1.50	.26	9.54**
Total		44	42.14	7.80	20.82	6.27	.29	16.74**

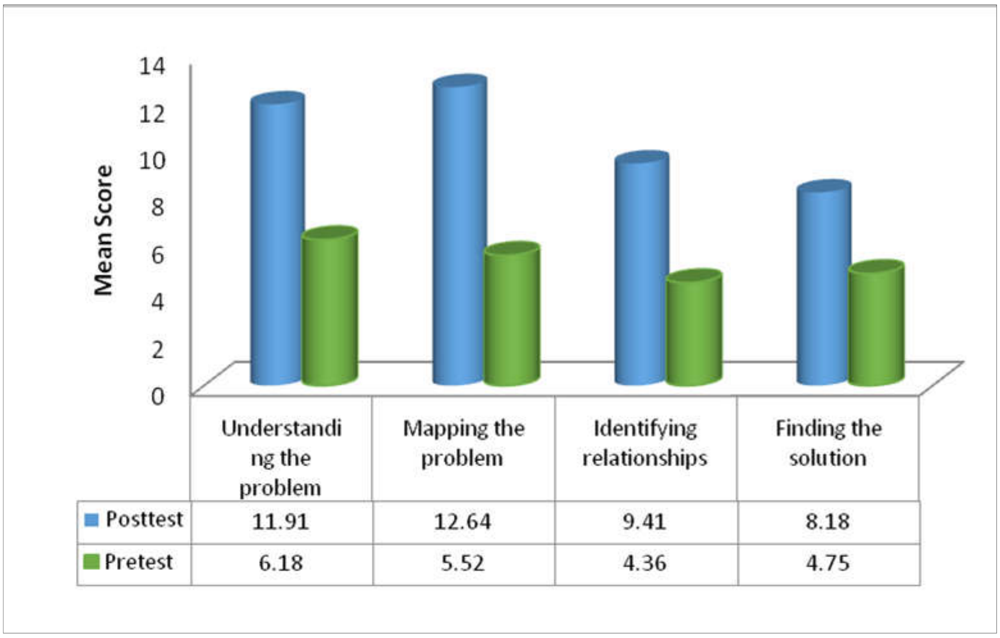
**$p<.01$

From Table 22, it is evident that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.695 for df 43 at .01 level of significance. So there is significant difference between pretest and posttest means of all the variables. The posttest means are greater than the corresponding pretest means for all the variables. The correlation coefficients indicate that there is substantial correlation between pretest and posttest scores of all the variables. This reveals that Virtual Learning Environment using Geogebra is effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample.

The pretest and posttest means of Problem solving ability in geometry (Understanding the problem, Mapping the problem, identifying relationships, Finding the solution and Total) for Total sample are presented graphically in figure 24

Figure 24

Comparison of Mean Pretest and Posttest Scores on Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of the Experimental Group for Total Sample



The graphical representation reveals that the mean performances of total sample in the pretest and posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are not similar. The posttest mean is greater than the pretest mean for all the variable.

Comparison of Mean Pretest and Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group for Subsample Boys

To compare the mean performance of subsample boys in experimental group on pretest and posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and

Total), the means and standard deviations of pretest and posttest scores were subjected to paired t test. The data and results of the test are given in Table 23.

Table 23

Results of Test of Significance of Difference in Mean Pretest Scores and Mean Posttest Scores of Problem Solving Ability in Geometry of Experimental Group – Subsample Boys

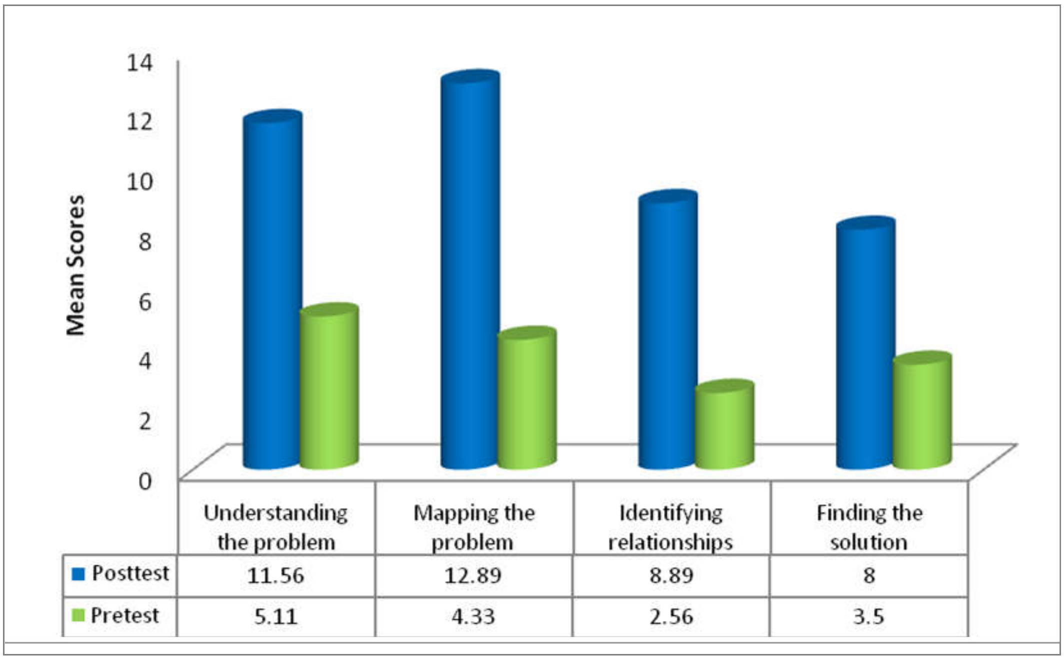
Variable		N	Experimental Group				r	t
			Posttest		Pretest			
			M_2	SD_2	M_1	SD_1		
Problem solving ability in geometry	Understanding the problem	18	11.56	2.38	5.11	1.57	.50	13.07**
	Mapping the problem	18	12.89	2.45	4.33	1.75	.07	11.67**
	Identifying relationships	18	8.89	2.63	2.56	1.58	.41	10.97**
	Finding the solution	18	8.00	2.57	3.50	0.79	.15	7.42**
Total		18	41.33	9.29	15.50	4.91	.34	12.33**

From Table 23, it is evident that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.878 for df 17 at .01 level of significance. So there is significant difference between pretest and posttest means of all the variables. The posttest test means are greater than the corresponding pretest means for all the variables. The correlation coefficients indicate that there is substantial positive correlation between pretest and posttest scores of all the variables. This reveals that Virtual Learning Environment using Geogebra is effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for subsample Boys.

The pretest and posttest means of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for subsample Boys are presented graphically in figure 25.

Figure 25

Comparison of Mean Pretest and Posttest Scores on Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) for Subsample Boys



The graphical representation reveals that the mean performances of subsample Boys in the pretest and posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are not similar. The posttest mean is greater than the pretest mean for all the variable.

Comparison of Mean Pretest and Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group for Subsample Girls

To compare the mean performance of subsample girls in experimental group on pretest and posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total), the means and standard deviations of pretest and posttest scores were subjected to paired t test. The data and results of the test are given in Table 24.

Table 24

Results of Test of Significance of Difference in Mean Pretest Scores and Mean Posttest Scores of Problem Solving Ability in Geometry of Experimental Group – Subsample Girls

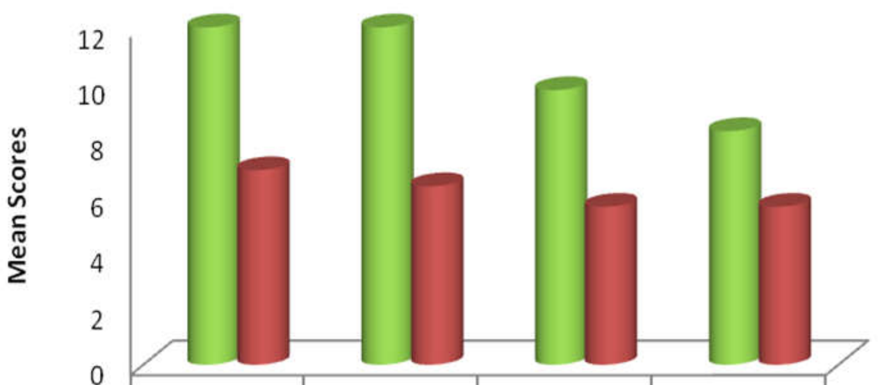
Variable		N	Experimental Group				r	t
			Posttest		Pretest			
			M_2	SD_2	M_1	SD_1		
Problem solving ability in geometry	Understanding the problem	26	12.15	1.78	6.92	1.44	.14	12.57^{**}
	Mapping the problem	26	12.46	1.33	6.35	1.85	.15	12.79^{**}
	Identifying relationships	26	9.77	2.49	5.62	1.88	.58	10.22^{**}
	Finding the solution	26	8.31	2.11	5.62	1.24	.40	6.95^{**}
Total		26	42.69	6.72	24.50	4.08	.32	13.95^{**}

From Table 24, it is evident that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.787 for df 25 at .01 level of significance. So there is significant difference between pretest and posttest means of all the variables. The posttest test means are greater than the corresponding pretest means for all the variables. The correlation coefficients indicate that there is substantial positive correlation between pretest and posttest scores of all the variables. This reveals that Virtual Learning Environment using Geogebra is effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for subsample Girls.

The pretest and posttest means of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for subsample Girls are presented graphically in figure 26

Figure 26

Comparison of Mean Pretest and Posttest Scores on Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) for Subsample Girls



	Understanding the problem	Mapping the problem	Identifying relationships	Finding the solution
Posttest	12.15	12.46	9.77	8.31
Pretest	6.92	6.35	5.62	5.62

The graphical representation reveals that the mean performances of subsample Girls in the pretest and posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are not similar. The posttest mean is greater than the pretest mean for all the variable

Discussion

There is significant difference between mean pretest and posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls. Mean posttest scores are significantly greater than mean pretest scores. Hence Virtual Learning Environment using Geogebra is effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls. The correlation coefficients show substantial positive relationship between pretest and posttest scores.

Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry of Experimental and Control Groups

To compare the post intervention status of the experimental and control groups with respect to the dependent variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total), test of significance of difference between means of two independent groups was used. The data and results of the test of significance of difference between means for Total sample, subsample Boys and subsample Girls are presented in the following sections.

Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group and Control Group for Total Sample

To compare the mean performance of Total sample in experimental group on pretest and posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total), independent sample t-test was used. The details of the test are given in Table 25.

Table 25

Results of Test of Significance of Difference in Mean Posttest Scores of Problem Solving Ability in Geometry between Experimental and Control Groups-Total Sample

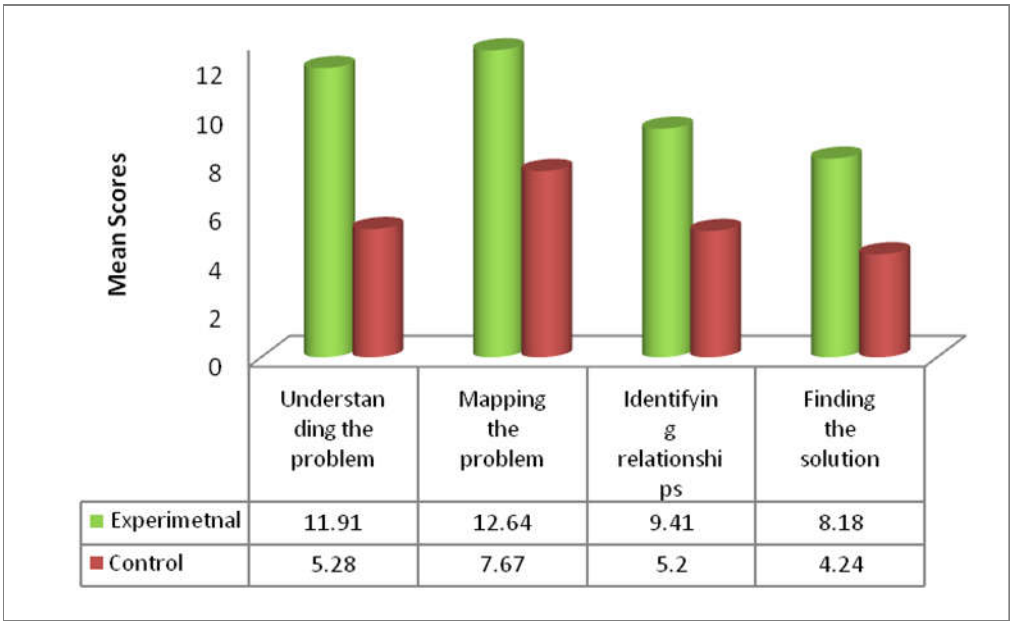
Variable		Experimental Group			Control Group			t
		N_1	M_{Exp}	SD_{Exp}	N_2	M_{Ctrl}	SD_{Ctrl}	
Problem Solving Ability in Geometry	Understanding the problem	44	11.91	2.04	46	5.28	2.48	13.79**
	Mapping the problem	44	12.64	1.86	46	7.67	2.25	11.38**
	Identifying relationships	44	9.41	2.56	46	5.20	2.62	7.72**
	Finding the solution	44	8.18	2.29	46	4.24	2.02	8.67**
	Total	44	42.14	7.80	46	22.39	8.10	11.78**

Table 25 shows that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.63 for df 88 at .01 level of significance. Thus the experimental and control groups differ significantly in the mean scores of Problem solving ability in geometry for Total sample after intervention and higher mean values are seen to associate with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry than conventional method of teaching for Total sample.

The mean posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Total sample are presented graphically in Figure 27

Figure 27

Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Total Sample



It is evident from Figure 27 that the mean performances on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of students in experimental and control groups are not similar and the mean posttest scores of experimental group are greater than those of control group for Total sample. Thus the results of mean difference analysis are supported by graphical representation also.

Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group and Control Group for Subsample Boys

To compare the mean performance of subsample Boys in experimental group and control group on posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total), independent sample t-test was used. The details of the test are given in Table 26

Table 26

Results of Test of Significance of Difference in Mean Posttest Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Boys

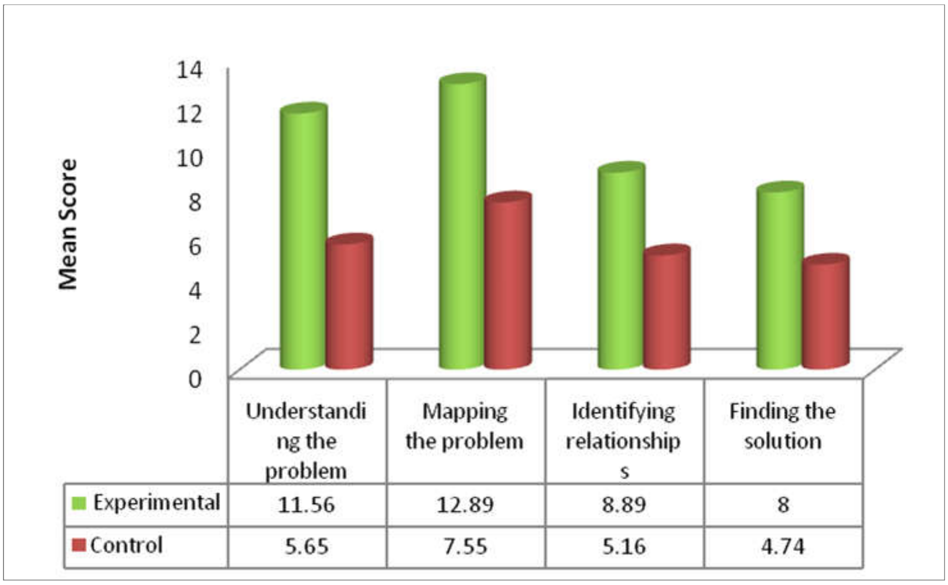
Variable		Experimental Group			Control Group			t
		N_1	M_{Exp}	SD_{Exp}	N_2	M_{Ctrl}	SD_{Ctrl}	
Problem Solving Ability in Geometry	Understanding the problem	18	11.56	2.38	31	5.65	2.48	8.15**
	Mapping the problem	18	12.89	2.45	31	7.55	2.45	7.37**
	Identifying relationships	18	8.89	2.63	31	5.16	3.05	4.33**
	Finding the solution	18	8.00	2.57	31	4.74	2.11	4.81**
	Total	18	41.33	9.29	31	23.10	8.97	6.76**

Table 26 shows that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.68 for df 47 at .01 level of significance. Thus the experimental and control groups differ significantly in the mean scores of Problem solving ability in geometry for subsample Boys after intervention and higher mean values are seen to associate with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry than conventional method of teaching for subsample Boys.

The mean posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for subsample Boys are presented graphically in Figure 28

Figure 28

Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Boys



It is evident from Figure 28 that the mean performances on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of students in experimental and control groups are not similar and the mean posttest scores of experimental group are greater than those of control group for subsample Boys. Thus the results of mean difference analysis are supported by graphical representation also.

Comparison of Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group and Control for Subsample Girls

To compare the mean performance of subsample Girls in experimental group and control group on posttest of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total), independent sample t-test was used. The details of the test are given in Table 27

Table 27

Results of Test of Significance of Difference in Mean Posttest Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Girls

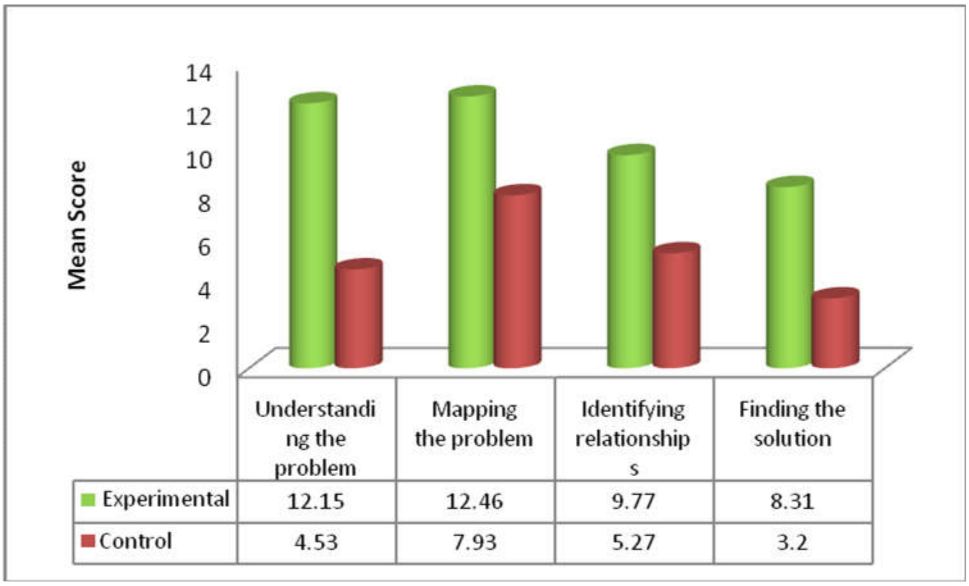
Variable		Experimental Group			Control Group			t
		N_1	M_{Exp}	SD_{Exp}	N_2	M_{Ctrl}	SD_{Ctrl}	
Problem Solving Ability in Geometry	Understanding the problem	26	12.15	1.78	15	4.53	2.39	11.64**
	Mapping the problem	26	12.46	1.33	15	7.93	1.83	9.12**
	Identifying relationships	26	9.77	2.49	15	5.27	1.49	6.37**
	Finding the solution	26	8.31	2.11	15	3.20	1.37	8.38**
	Total	26	42.69	6.72	15	20.93	5.85	10.46**

Table 27 reveals that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.71 for df 39 at .01 level of significance. Thus the experimental and control groups differ significantly in the mean scores of Problem solving ability in geometry for subsample Girls after intervention and higher mean values are seen to associate with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry than existing method of teaching for subsample Girls.

The mean posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for subsample Girls are presented graphically in Figure 29

Figure 29

Comparison of Mean Posttest Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Girls



It is evident from Figure 29 that the mean performances on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of students in experimental and control groups are not similar and the mean posttest scores of experimental group are greater than those of control group for subsample Girls. Thus the results of mean difference analysis are supported by graphical representation also.

Discussion

The mean difference analysis of posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) yields the following inferences.

There is significant difference between mean posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Total sample, subsample Boys and subsample Girls. Higher mean values are seen to associate with experimental group for Total sample, subsample Boys and subsample Girls.

Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) than existing method of teaching for Total sample, subsample Boys and subsample Girls

Comparison of Mean Gain Scores of Problem Solving Ability in Geometry of Experimental and Control Groups

To compare the post intervention status of the experimental and control groups with respect to the dependent variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total), test of significance of difference between means of two independent groups was used. The data and results of the test of significance of difference between mean gain scores for Total sample subsample Boys and subsample Girls are presented in the following sections.

Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group and Control Group for Total Sample

To check whether there exists significant difference between mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of the experimental and control groups for Total sample, means and standard deviations of the gain scores of the two groups were calculated and subjected to independent sample t-test. The results are shown in Table 28.

Table 28

Results of Test of Significance of Difference in Mean Gain Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Total Sample

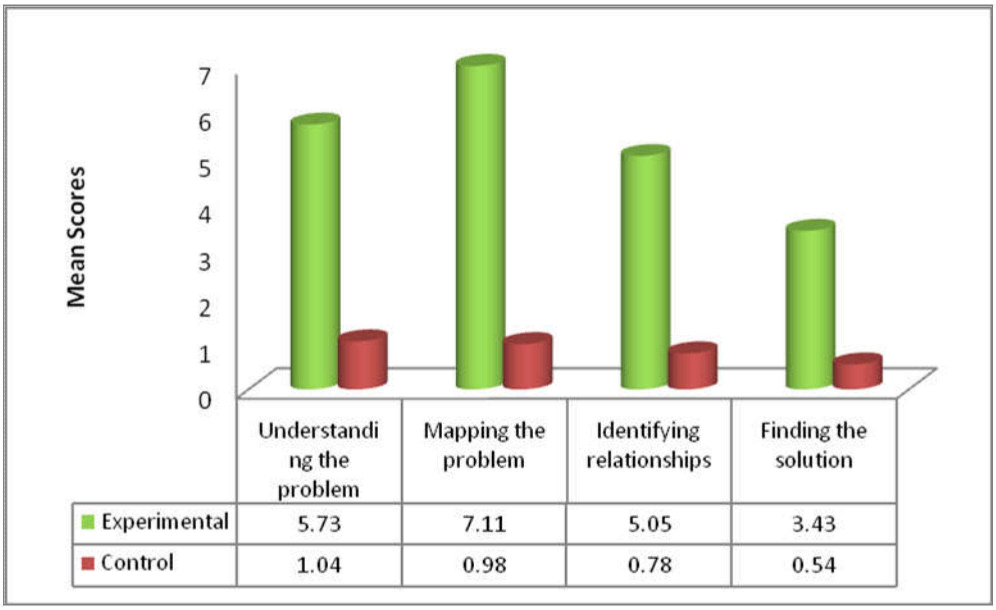
Variable		Experimental Group			Control Group			t
		N_1	M_{Exp}	SD_{Exp}	N_2	M_{Ctrl}	SD_{Ctrl}	
Problem Solving Ability in Geometry	Understanding the problem	44	5.73	2.17	46	1.04	1.96	10.77**
	Mapping the problem	44	7.11	2.96	46	0.98	1.77	11.99**
	Identifying relationships	44	5.05	2.46	46	0.78	1.99	9.04**
	Finding the solution	44	3.43	2.39	46	0.54	1.83	6.46**
Total		44	21.32	8.45	46	3.35	4.25	12.83**

Table 28 reveals that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.63 for df 88 at .01 level of significance. Thus the experimental and control groups differ significantly in the mean gain scores of Problem solving ability in geometry for Total sample after intervention and higher mean values are seen to associate with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry than conventional method of teaching for Total sample.

The mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Total sample are presented graphically in Figure 30

Figure 30

Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Total Sample



It is evident from Figure 30 that the mean performances on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of students in experimental and control groups are not similar and the mean gain scores of experimental group are greater than those of control group for Total sample. Thus the results of mean difference analysis are supported by graphical representation also.

Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group and Control Group for Subsample Boys

To check whether there exists significant difference between mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of the experimental and control groups for subsample Boys, means and standard deviations of the gain scores of the two groups were calculated and subjected to independent sample t-test. The results are shown in Table 29.

Table 29

Results of Test of Significance of Difference in Mean Gain Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Boys

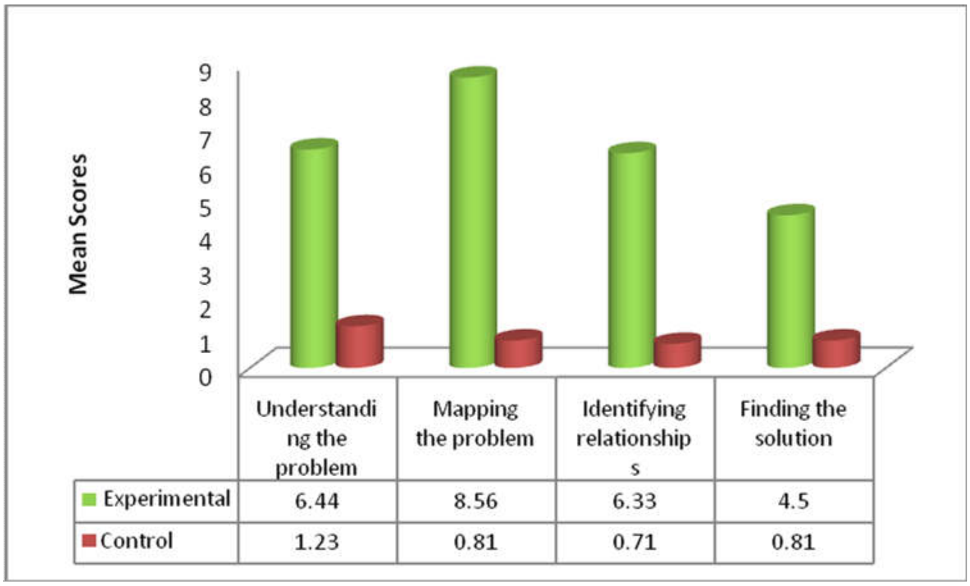
Variable		Experimental Group			Control Group			t
		N_1	M_{Exp}	SD_{Exp}	N_2	M_{Ctrl}	SD_{Ctrl}	
Problem Solving Ability in Geometry	Understanding the problem	18	6.44	2.09	31	1.23	2.11	8.37**
	Mapping the problem	18	8.56	3.11	31	0.81	1.74	11.22**
	Identifying relationships	18	6.33	2.45	31	0.71	2.25	8.16**
	Finding the solution	18	4.50	2.57	31	0.81	1.83	5.85**
Total		18	25.83	8.89	31	3.55	4.90	11.35**

Table 29 reveals that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.63 for df 88 at .01 level of significance. Thus the experimental and control groups differ significantly in the mean gain scores of Problem solving ability in geometry for subsample boys and higher mean values are seen to associate with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry than conventional method of teaching for subsample Boys.

The mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for subsample Boys are presented graphically in Figure 31

Figure 31

Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Boys



It is evident from Figure 31 that the mean performances on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of students in experimental and control groups are not similar and the mean gain scores of experimental group are greater than those of control group for subsample Boys. Thus the results of mean difference analysis are supported by graphical representation also.

Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental Group and Control Group for Subsample Girls

To check whether there exists significant difference between mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of the experimental and control groups for subsample Girls, means and standard deviations of the gain scores of the two groups were calculated and subjected to test independent sample t-test. The results are shown in Table 30.

Table 30

Results of Test of Significance of Difference in Mean Gain Scores of Problem Solving Ability in Geometry between Experimental and Control Groups – Subsample Girls

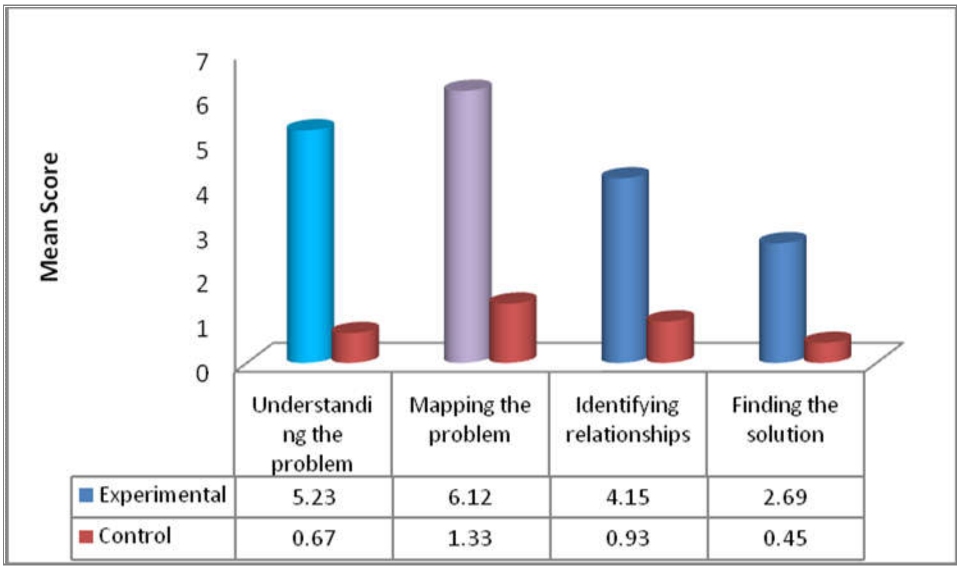
Variable		Experimental Group			Control Group			t
		N_1	M_{Exp}	SD_{Exp}	N_2	M_{Ctrl}	SD_{Ctrl}	
Problem Solving Ability in Geometry	Understanding the problem	26	5.23	2.12	15	0.67	1.59	7.23**
	Mapping the problem	26	6.12	2.44	15	1.33	1.84	6.58**
	Identifying relationships	26	4.15	2.07	15	0.93	1.39	5.35**
	Finding the solution	26	2.69	1.98	15	0.45	1.77	4.36**
	Total	26	18.19	6.65	15	2.93	2.52	8.50**

Table 30 reveals that the calculated t values for Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are greater than the table value 2.71 for df 39 at .01 level of significance. Thus the experimental and control groups differ significantly in the mean gain scores of Problem solving ability in geometry for subsample Girls after intervention and higher mean values are seen to associate with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry than conventional method of teaching for subsample Girls.

The mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for subsample Girls are presented graphically in Figure 32

Figure 32

Comparison of Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Girls



It is evident from Figure 32 that the mean performances on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of students in experimental and control groups are not similar and the mean gain scores of experimental group are greater than those of control group for subsample Girls. Thus the results of mean difference analysis are supported by graphical representation also.

Discussion

The mean difference analysis of mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) yields the following inferences.

There is significant difference between mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Total sample, subsample Boys and subsample Girls. Higher mean values are seen to associate with experimental group for Total sample, subsample Boys and subsample Girls.

Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) than conventional method of teaching for Total sample, subsample Boys and subsample Girls.

Genuineness of the Difference between Experimental and Control Groups

It is found that the experimental group taught through Virtual Learning Environment using Geogebra performed better on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) than the control group taught through Conventional Method of Teaching. Hence it can be tentatively concluded that Virtual Learning Environment using Geogebra is superior in improving Problem solving ability in geometry to the Conventional Method of Teaching. In order to ensure the genuineness of difference, the results were substantiated using the technique of Analysis of Covariance. The details of the analysis are presented in the following sections.

By employing one-way ANCOVA, the investigator could further study the relative effectiveness of Virtual Learning Environment using Geogebra and Conventional Method of Teaching in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample and subsamples based on Gender after controlling the effect of covariate Non-verbal Intelligence. The independent variable of the study is instructional strategy and its two levels are Virtual Learning Environment using Geogebra and Conventional Method of Teaching. Hence Virtual

Learning Environment using Geogebra and Conventional Method were incorporated in the ANCOVA as the two levels of independent variable. Scores of Non-verbal Intelligence was taken as covariate. The gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) were considered as dependent variables.

Tests for Basic Assumptions

The collected data were analyzed to check whether they follow basic assumptions of ANCOVA.

Linear Relationship between the Dependent Variable and Covariates

The nature of the relationship between dependent variables and covariates was studied using Scatter Plots. The scatter plots of the dependent variable, gain score on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) against covariate Non-verbal Intelligence for Total sample, subsample Boys and subsample Girls were drawn.

The scatter plots of the dependent variables against the covariate for Total sample, subsample Boys and subsample Girls are presented in Figure 33, Figure 34 and Figure 35 respectively.

Figure 33

The Scatter Plots of the Dependent Variables Against the Covariate for Total Sample

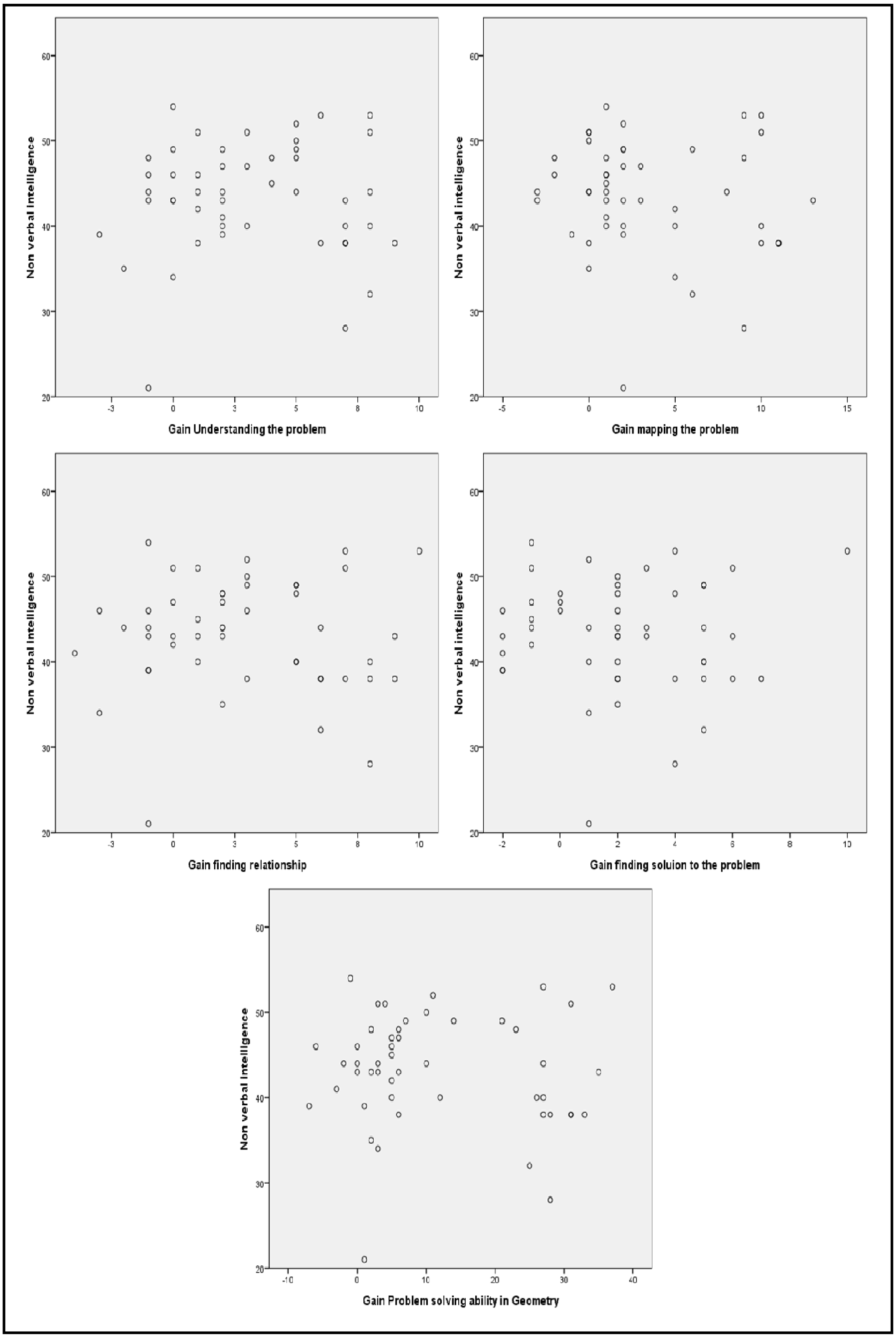


Figure 34

The Scatter Plots of the Dependent Variables against the Covariate for the Subsample Boys

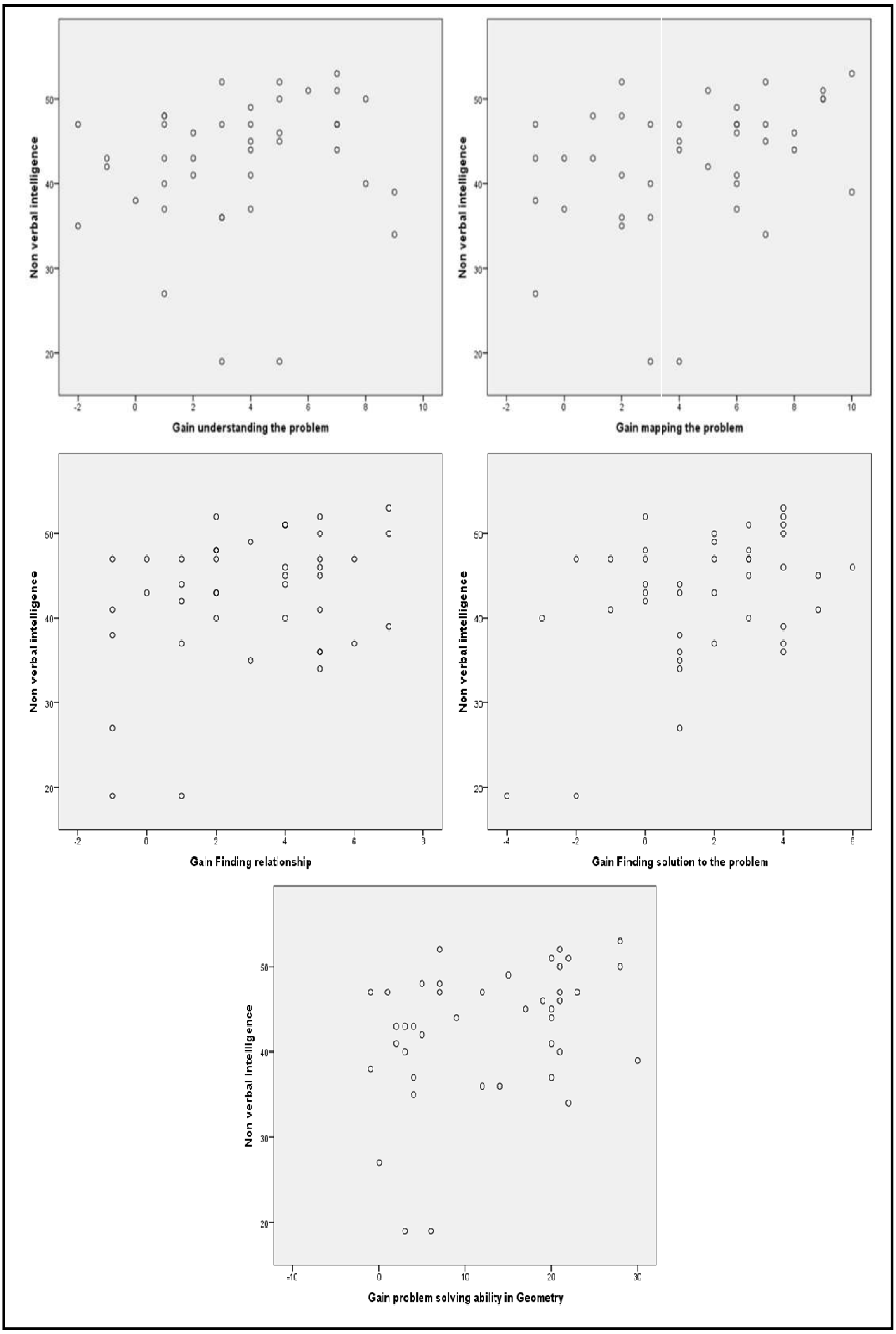
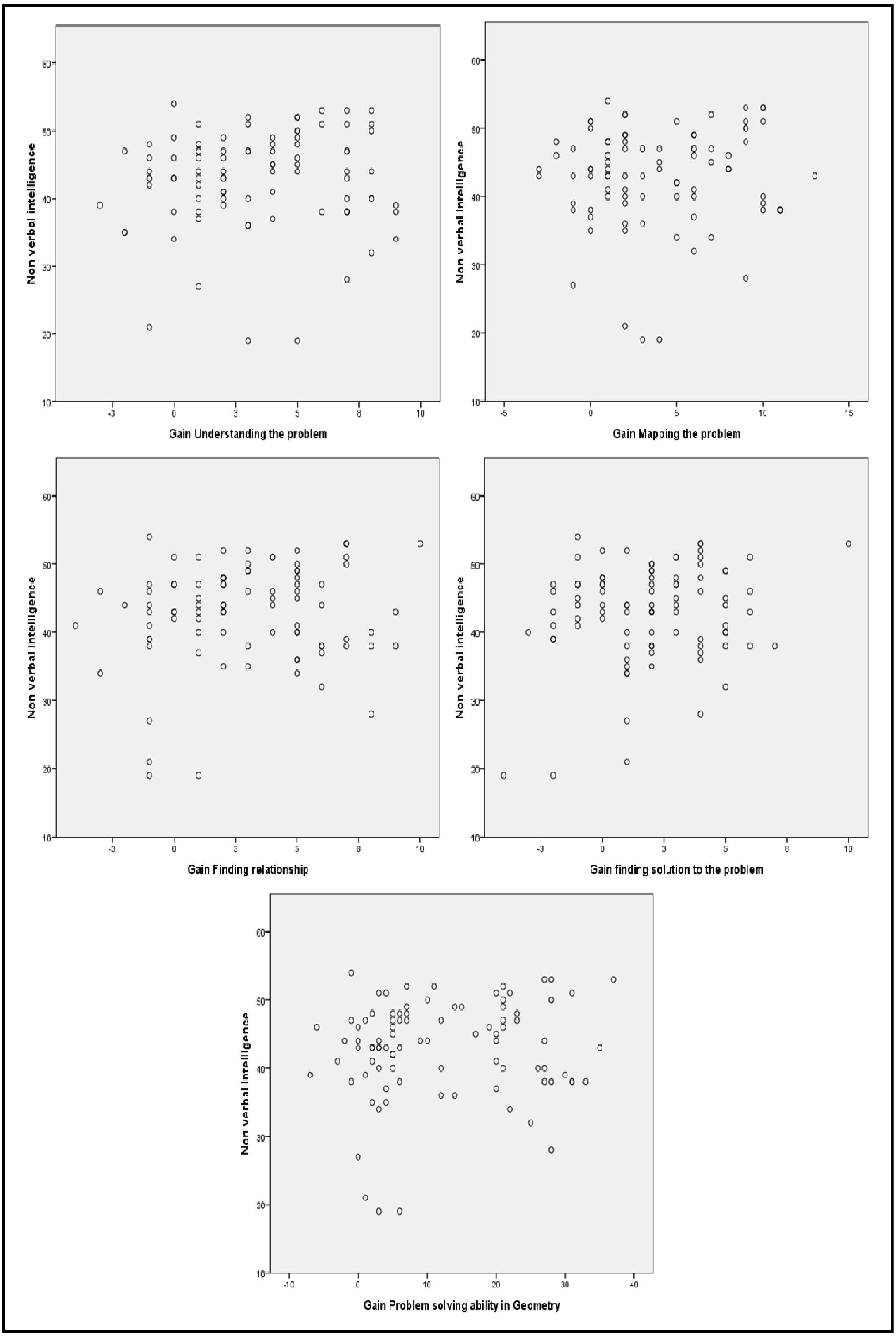


Figure 35

The Scatter Plots of the Dependent Variables against the Covariate for the Subsample Girls



A visual inspection of the scatter plots given in Figure 33, Figure 34 and Figure 35 revealed that there is linear relationship between dependent variables and covariates for Total sample, subsample Boys and subsample Girls.

Homogeneity of Variances

Levene's test of equality of error variances was employed to test homogeneity of variances of experimental and control groups. The test checks whether the variances of two groups significantly differ or not. Homogeneity of variance of experimental and control groups on dependent variables Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) was tested for Total sample, subsample Boys and subsample Girls. Results of Levene's test are presented in Table 31.

Table 31

Results of Levene's Test for Problem solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) – Total Sample, Subsample Boys and Subsample Girls

Variable	Sample	Variable	Levene's F	df1	df2	Significance Level
Problem solving ability in geometry	Total	Understanding the problem	3.703	1	88	.058
		Mapping the problem	4.733	1	88	.032
		Identifying relationships	.490	1	88	.486
		Finding the solution	.367	1	88	.546
		Total	1.020	1	88	.315
	Boys	Understanding the problem	.145	1	47	.705
		Mapping the problem	1.198	1	47	.279
		Identifying relationships	1.454	1	47	.234
		Finding the solution	.570	1	47	.454
		Total	.116	1	47	.735
	Girls	Understanding the problem	3.464	1	39	.070
		Mapping the problem	1.276	1	39	.265
		Identifying relationships	2.545	1	39	.119
		Finding the solution	1.255	1	39	.269
		Total	.015	1	39	.902

Table 31 implies that the variances of experimental and control group are almost equal. Thus the assumption of homogeneity of variance for ANCOVA is satisfied to a certain degree for the dependent variables in Total sample, subsample Boys and subsample Girls.

Comparison of the Adjusted Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Total Sample and Subsamples based on Gender

One-way ANCOVA was used to study whether there exists any significant difference between gain scores of experimental and control groups with respect to Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) after adjusting for the initial differences if any, by taking Non-verbal Intelligence as covariate. Bonferroni's test of post hoc comparison was done for ANCOVA with significant F value. The details of ANCOVA of the dependent variable Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) and effect size in terms of Partial eta squared for Total sample, subsample Boys and subsample Girls are given in the following sections.

Comparison of the Adjusted Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Total Sample

One way ANCOVA was done to find out whether significant difference exists in the adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample by taking Non-verbal Intelligence as covariate. The data and results of the covariance analysis of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample are presented in Table 32.

Table 32

Summary of Analysis of Covariance of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Non-verbal Intelligence as Covariate for Total Sample

Variables	Source of Variance	Sum of Squares	Df	Mean Squares	F	Level of Significance	Partial eta squared
Understanding the problem	Between Groups	492.95	1	492.95	115.77	<.001	.571
	Within Groups	370.44	87	4.26			
	Total	868.00	89				
Mapping the problem	Between Groups	846.22	1	846.22	142.69	<.001	.621
	Within Groups	515.94	87	5.93			
	Total	1363.96	89				
Identifying relationships	Between Groups	408.02	1	408.02	83.08	<.001	.488
	Within Groups	427.26	87	4.91			
	Total	848.4	89				
Finding the solution	Between Groups	187.07	1	187.07	43.23	<.001	.332
	Within Groups	376.48	87	4.33			
	Total	583.82	89				
Total	Between Groups	7253.79	1	7253.79	168.03	<.001	.659
	Within Groups	3755.75	87	43.17			
	Total	11144.44	89				

Table 32 indicates that the obtained F values those are $F (1, 87) = 115.77$, $p < .001$, $\eta_p^2 = .571$; $F (1, 87) = 142.69$, $p < .001$, $\eta_p^2 = .621$; $F (1, 87) = 83.08$, $p < .001$, $\eta_p^2 = .488$; $F (1, 87) = 43.23$, $p < .001$, $\eta_p^2 = .332$; $F (1, 87) = 168.03$, $p < .001$, $\eta_p^2 = .659$; for the effect of instructional strategy on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) respectively after controlling the effect of Non-verbal Intelligence are significant at .01 level of significance. This implies that there is significant difference between mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups after controlling the effects of covariate. Thus the difference in mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Total sample can be attributed to the effect of instructional strategy. Post hoc comparison of adjusted means of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Total sample, Test of significance of difference between adjusted means was done to find out whether the experimental and control groups differ significantly with respect to adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample. The details of post hoc comparison of adjusted mean scores are given in Table 33.

Table 33

Results of the Bonferroni's Test of Post Hoc Comparison between the Adjusted Means of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Total Sample

Dependent Variable	Experimental Group		Control Group		Std Error	t
	N	Adjusted Mean	N	Adjusted Mean		
Understanding the problem	44	5.73	46	1.04	0.44	10.76
Mapping the problem	44	7.11	46	0.98	0.51	11.95
Identifying relationships	44	5.04	46	0.78	0.47	9.12
Finding the solution	44	3.43	46	0.55	0.44	6.58
Total	44	21.31	46	3.35	1.39	12.96

From the Table 33 it is clear that the calculated t values are found to be significant at .01 level as the values are greater than 2.58, table value of t at .01 level. Thus there is significant difference between adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) between experimental and control groups for Total sample. It is to be noted that high means are associated with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) than Existing Method of Teaching for Total sample.

Comparison of the Adjusted Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Boys

One way ANCOVA was done to find out whether significant difference exists in the adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for subsample Boys by taking Non-verbal Intelligence as covariate. The data and results of the covariance analysis of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample are presented in Table 34

Table 34

Summary of Analysis of Covariance of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Non-verbal Intelligence as Covariate for Subsample Boys

Variables	Source of Variance	Sum of Squares	df	Mean Squares	F	Level of Significance	Partial eta squared
Understanding the problem	Between Groups	417.66	1	417.66	47.92	<.001	.620
	Within Groups	256.43	46	5.58			
	Total	679.35	48				
Mapping the problem	Between Groups	333.95	1	333.95	56.51	<.001	.551
	Within Groups	271.86	46	5.91			
	Total	606.25	48				
Identifying relationships	Between Groups	178.20	1	178.20	23.26	<.001	.336
	Within Groups	352.48	46	7.66			
	Total	554.20	48				
Finding the solution	Between Groups	136.40	1	136.40	29.64	<.001	.392
	Within Groups	211.73	46	4.60			
	Total	366.82	48				
Total	Between Groups	4062.73	1	4062.73	53.88	<.001	.539
	Within Groups	3468.35	46	75.4			
	Total	7677.96	48				

Table 34 indicates that the obtained F values, $F(1, 46) = 47.92$, $p < .001$, $\eta_p^2 = .620$; $F(1, 46) = 56.51$, $p < .001$, $\eta_p^2 = .551$; $F(1, 46) = 23.26$, $p < .001$, $\eta_p^2 = .336$; $F(1, 46) = 29.64$, $p < .001$, $\eta_p^2 = .392$; $F(1, 46) = 53.88$, $p < .001$, $\eta_p^2 = .539$; for the effect of instructional strategy on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) respectively after controlling the effects of Non-verbal Intelligence are significant at .01 level of significance. This implies that there is significant difference between gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups after controlling the effects of covariate. Thus the difference in gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for subsample boys can be attributed to the effect of instructional strategy. Post hoc comparison of adjusted means of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total)of experimental and control groups for subsample boys, Test of significance of difference between adjusted means was done to find out whether the experimental and control groups differ significantly with respect to adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for subsample boys. The details of post hoc comparison of adjusted mean scores are given in Table 35.

Table 35

Results of the Bonferroni's Test of Post Hoc Comparison between the Adjusted Means of Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) – Subsample Boys

Dependent Variable	Experimental Group		Control Group		Std Error	t
	N	Adjusted mean	N	Adjusted mean		
Understanding the problem	18	6.51	31	1.18	0.63	8.51
Mapping the problem	18	8.51	31	0.83	0.70	10.97
Identifying relationships	18	6.39	31	0.68	0.70	8.22
Finding the solution	18	4.54	31	0.79	0.64	5.86
Total	18	25.95	31	3.48	1.99	11.29

From the Table 35 it is clear that the calculated t values are found to be significant at .01 level as the values are greater than 2.58, table value of t at .01 level. Thus there is significant difference between adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) between experimental and control groups for subsample boys. It is to be noted that high means are associated with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) than Existing Method of Teaching for subsample boys.

Comparison of the Adjusted Mean Gain Scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) of Experimental and Control Groups for Subsample Girls

One way ANCOVA was done to find out whether significant difference exists in the adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Subsample girls by taking Non-verbal Intelligence as covariate. The data and results of the covariance analysis of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Subsample girls are presented in Table 36

Table 36

Summary of Analysis of Covariance of Gain scores of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) - Non-verbal Intelligence as Covariate for Subsample Girls

Variables	Source of Variance	Sum of Squares	df	Mean Squares	F	Level of Significance	Partial eta squared
Understanding the problem	Between Groups	190.22	1	190.22	48.94	<.001	.563
	Within Groups	147.69	38	3.89			
	Total	346.10	40				
Mapping the problem	Between Groups	190.87	1	190.87	40.89	<.001	.518
	Within Groups	177.37	38	4.67			
	Total	413.51	40				
Identifying relationships	Between Groups	84.62	1	84.62	26.39	<.001	.410
	Within Groups	121.83	38	3.21			
	Total	232.98	40				
Finding the solution	Between Groups	54.33	1	54.33	17.51	<.001	.315
	Within Groups	117.93	38	3.10			
	Total	210.49	40				
Total	Between Groups	1951.63	1	1951.63	72.68	<.001	.657
	Within Groups	1020.36	38	26.85			
	Total	3409.76	40				

Table 36 indicates that the obtained F values, F (1, 38) = 48.94, p <.001, η_p^2 = .563; F (1, 38) = 40.89, p <.001, η_p^2 = .518; F (1, 38) = 26.39, p <.001, η_p^2= .410; F (1, 38) = 17.51, p <.001, η_p^2 = .315; F (1, 38) = 72.68, p <.001, η_p^2= .657; for the effect of instructional strategy on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) respectively after controlling the effect of Non-verbal Intelligence are significant at .01 level of significance. This implies that there is significant difference between gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups after controlling the effects of covariate. Thus the difference in gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Subsample girls can be attributed to the effect of instructional strategy. Post hoc comparison of adjusted means of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of experimental and control groups for Subsample girls, Test of significance of difference between adjusted means was done to find out whether the experimental and control groups differ significantly with respect to adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Subsample girls. The details of post hoc comparison of adjusted mean scores are given in Table 37.

Table 37

Results of the Bonferroni's Test of Post Hoc Comparison between the Adjusted Means of Problem Solving Ability in Geometry (Understanding the Problem, Mapping the Problem, Identifying Relationships, Finding the Solution and Total) – Subsample Girls

Dependent Variable	Experimental Group		Control Group		Std Error	t
	N	Adjusted Mean	N	Adjusted Mean		
Understanding the problem	26	5.22	15	0.68	0.65	7.00
Mapping the problem	26	6.03	15	1.48	0.71	6.40
Identifying relationships	26	4.08	15	1.06	0.59	5.14
Finding the solution	26	2.59	15	0.17	0.58	4.18
Total	26	17.93	15	3.40	1.70	8.53

From the Table 37 it is clear that the calculated t values are found to be significant at .01 level as the values are greater than 2.58, table value of t at .01 level. Thus there is significant difference between adjusted mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) between experimental and control groups for Subsample girls. It is to be noted that high means are associated with experimental group. Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) than Existing Method of Teaching for Subsample girls.

Summary and Discussion of Analysis of Covariance of the Dependent Variables

Results of ANCOVA used to study the effect of Instructional Strategy – Virtual Learning Environment using Geogebra on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) after controlling the effects of the covariate Non-verbal Intelligence are presented in the following sections.

The F values obtained for ANCOVA, t values of post hoc comparison and effect size in terms of partial eta squared for Total sample, subsample Boys and subsample Girls are presented in Table 38, Table 39 and Table 40 respectively.

Table 38

Summary of ANCOVA of the Dependent Variables – Total Sample

Source of Variation	Dependent Variable		F	t	Level of Significance	Partial eta squared
Instructional Strategy (Virtual Learning Environment using Geogebra)	Problem Solving Ability	Understanding the problem	115.77	10.76	.001	.571
		Mapping the problem	142.69	11.95	.001	.621
		Identifying relationships	83.08	9.12	.001	.488
		Finding the solution	43.23	6.58	.001	.332
		Total	168.03	12.96	.001	.659

Table 39

Summary of ANCOVA of the Dependent Variables – Subsample Boys

Source of Variation	Dependent Variable		F	t	Level of Significance	Partial eta squared
Instructional Strategy (Virtual Learning Environment using Geogebra)	Problem Solving Ability	Understanding the problem	47.92	8.51	.001	.620
		Mapping the problem	56.51	10.97	.001	.551
		Identifying relationships	23.26	8.22	.001	.336
		Finding the solution	29.64	5.86	.001	.392
		Total	53.88	11.29	.001	.539

Table 40

Summary of ANCOVA of the Dependent Variables – Subsample Girls

Source of Variation	Dependent Variable		F	t	Level of Significance	Partial eta squared
Instructional Strategy (Virtual Learning Environment using Geogebra)	Problem Solving Ability	Understanding the problem	48.94	7.00	.001	.563
		Mapping the problem	40.89	6.40	.001	.518
		Identifying relationships	26.39	5.14	.001	.410
		Finding the solution	17.51	4.18	.001	.315
		Total	72.68	8.53	.001	.657

From Table 38, Table 39 and Table 40, it is evident that there is significant difference between experimental and control groups with respect to Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) even after controlling effects of covariate for Total sample, subsample Boys and subsample Girls.

Hence it can be concluded that Virtual Learning Environment Using Geogebra is more effective than Conventional method of teaching in improving Problem Solving Ability in Geometry – component wise (Understanding the problem, Mapping the problem, Identifying relationships and Finding the solution) and total of secondary school students for Total sample, subsample Boys and subsample Girls.

Chapter **5**

SUMMARY, FINDINGS & CONCLUSIONS

- *Study in Retrospect*
- *Major Findings of the Study*
- *Tenability of Hypotheses*
- *Conclusion*

SUMMARY, FINDINGS AND CONCLUSION

A brief description of the procedure followed in the study, summary of major findings, educational implications of the findings and suggestions for further research are included in this chapter.

Study in Retrospect

In this section a look back to the title, variables, objectives, hypotheses, tools, and statistical techniques of the study has been carried out.

Restatement of the Problem

The present study was undertaken to develop and to find the effect of the Instructional Strategy, Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students. Hence the study is entitled as **"Effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students."**

Variables

The variables of the present study were as follows

Dependent Variable

Problem Solving Ability (Total Score and component wise score) was treated as the dependent variable in the present study.

Component of the dependent variable Problem Solving Ability were

1. Understanding the Problem
2. Mapping the Problem

3. Identifying relationships
4. Finding Solution

Independent Variable

The Independent Variable for the present study was the Instructional strategy. The two levels of the Instructional Strategy used were as follows.

- Virtual Learning Environment with Geogebra
- Conventional Instructional Strategy

Controlled Variable

Control Variable considered for this study was Non-verbal Intelligence.

Objectives

The objectives of the present study were presented below as general objectives and specific objectives.

General Objectives

1. To develop a Virtual Learning Environment using Geogebra on geometry for secondary school students.
2. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School students

Specific Objectives

1. To find out the effect of Virtual Learning Environment using Geogebra on first component of Problem Solving Ability (Understanding the Problem) in Geometry of Secondary School students for the total group and subgroups based on gender.

2. To find out the effect of Virtual Learning Environment using Geogebra on second component of Problem Solving Ability (Mapping the Problem) in Geometry of Secondary School Students for the total group and subgroups based on gender.
3. To find out the effect of Virtual Learning Environment using Geogebra on third component of Problem Solving Ability (Identifying relationships) in Geometry of Secondary School Students for the total group and subgroups s based on gender.
4. To find out the effect of Virtual Learning Environment using Geogebra on fourth component of Problem Solving Ability (Finding the solution to the problem) in Geometry of Secondary School Students for the total group and subgroups based on gender.
5. To find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability (Total) in Geometry of Secondary School Students for the total group and subgroups based on gender.
6. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on first component of Problem Solving Ability (Understanding the Problem) in geometry of Secondary School Students for the total group and subgroups based on gender.
7. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on second component of Problem Solving Ability (Mapping the Problem) in geometry of Secondary School Students for the total group and subgroups based on gender.

8. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on third component of Problem Solving Ability (Identifying relationships) in geometry of Secondary School Students for the total group and subgroups based on gender.

9. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on fourth component of Problem Solving Ability (Finding solution to the problem) in geometry of Secondary School Students for the total group and subgroups based on gender.

10. To compare the effect of Virtual Learning Environment using Geogebra and Conventional Instructional strategy with Non verbal intelligence as covariate, on Problem Solving Ability (Total) in Geometry of Secondary School Students for the total group and subgroups based on gender.

Hypotheses of the Study

1. Virtual Learning Environment using Geogebra has significant effect on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender

2. Virtual Learning Environment using Geogebra has significant effect on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender

3. Virtual Learning Environment using Geogebra has significant effect on ability to Identify Relationships in the problem in Geometry of

Secondary School Students for the total group and subgroups based on gender

4. Virtual Learning Environment using Geogebra has significant effect on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender

5. Virtual Learning Environment using Geogebra has significant effect on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender

6. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

7. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

8. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Identify Relationships in the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

9. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

10. There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Methodology

The study intended to find out the effect of the Instructional Strategy, Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students, adopted Experimental method.

Design of the Study

The design selected for the study was Quasi experimental Pre-test Post-test Nonequivalent group design.

Samples Selected for the Study

A total of 90 students from two divisions of standard IX of Al- Anvar High School Kuniyil, Malappuram District of Kerala state were selected for the conduct of the study. Subjects were not assigned randomly since intact classrooms were assigned as experimental and control groups to conduct the experimentation without collapsing the order of functioning of the school.

Tools Used for the Study

The data required for this study was collected using the following tools.

- Problem Solving Ability Test (Rishad & Praveen, 2019)
- Virtual Learning Environment using Geogebra (Rishad & Praveen, 2019)
- Lesson Transcripts on Conventional Instructional Strategy (Rishad & Praveen, 2019)
- Non verbal Intelligence test- Raven's Standard Progressive Matrices (Raven, 1958)

Major Findings of the Study

The results of the experiment conducted to study Effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students are presented in the following sections

Virtual Learning Environment using Geogebra has significant effect in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of Secondary School Students belonging to Experimental Group for Total Sample, Subsample Boys and Subsample Girls

The mean posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of secondary school students belonging to experimental group is greater than the mean pretest scores for Total sample, sub sample Boys and sub sample Girls. The difference between the mean pretest and posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) is significant for Total sample, subsample Boys and subsample Girls.

Understanding the problem –

Total Pretest and posttest: M_{Pre}= 6.18, M_{Post}= 11.91; t = 17.50, p<.01

Boys Pretest and posttest: M_{Pre} = 5.11, M_{Post} = 11.56; t = 13.07, p<.01

Girls Pretest and posttest: M_{Pre} = 6.92, M_{Post} = 12.15; t = 12.57, p<.01

Mapping the problem –

Total Pretest and posttest: M_{Pre} = 5.52, M_{Post} = 12.64; t = 15.95, p<.01

Boys Pretest and posttest: M_{Pre} = 4.33, M_{Post} = 12.89; t = 11.67, p<.01

Girls Pretest and posttest: M_{Pre} = 6.35, M_{Post} = 12.46; t = 12.79, p<.01

Identifying relationships –

Total Pretest and posttest: MPre = 4.36, MPost = 9.41; t =13.61 , p<.01

Boys Pretest and posttest: MPre = 2.56, MPost = 8.89; t = 10.97, p<.01

Girls Pretest and posttest: MPre = 5.62, MPost = 9.77; t = 10.22, p<.01

Finding the solution –

Total Pretest and posttest: MPre = 4.75, MPost = 8.18; t = 9.54, p<.01

Boys Pretest and posttest: MPre = 3.50, MPost = 8.00; t = 7.42, p<.01

Girls Pretest and posttest: MPre = 5.62, MPost = 8.31; t = 6.95, p<.01

Total –

Total Pretest and posttest: MPre = 20.82, MPost =42.14 ; t = 16.74, p<.01

Boys Pretest and posttest: MPre = 15.50, MPost =41.33; t = 12.33, p<.01

Girls Pretest and posttest: MPre = 24.50, MPost = 42.69; t = 13.95, p<.01

Hence Virtual Learning Environment using Geogebra is effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of secondary school students in the experimental group for Total sample, subsample Boys and subsample Girls.

Virtual Learning Environment using Geogebra is more effective than Conventional Method of Teaching in Improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of Secondary School Students for Total Sample, Subsample Boys and Subsample Girls

The mean posttest scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of secondary school students belonging to experimental group are greater than the corresponding posttest scores of the control group for Total sample, subsample Boys and subsample Girls. The differences between the mean posttest scores of experimental and control groups on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are significant for Total sample, subsample Boys and subsample Girls.

Understanding the problem –

Total Posttest: $M_{Exp} = 11.91$, $M_{Ctrl} = 5.28$; $t = 13.79$, $p<.01$

Boys Posttest: $M_{Exp} = 11.56$, $M_{Ctrl} = 5.65$; $t = 8.15$, $p<.01$

Girls Posttest: $M_{Exp} = 12.15$, $M_{Ctrl} = 4.53$; $t = 11.64$, $p<.01$

Mapping the problem –

Total Posttest: $M_{Exp} = 12.64$, $M_{Ctrl} = 7.67$; $t = 11.38$, $p<.01$

Boys Posttest: $M_{Exp} = 12.89$, $M_{Ctrl} = 7.55$; $t = 7.37$, $p<.01$

Girls Posttest: $M_{Exp} = 12.46$, $M_{Ctrl} = 7.93$; $t = 9.12$, $p<.01$

Identifying relationships –

Total Posttest: $M_{Exp} = 9.41$, $M_{Ctrl} = 5.20$; $t = 7.72$, $p<.01$

Boys Posttest: $M_{Exp} = 8.89$, $M_{Ctrl} = 5.16$; $t = 4.33$, $p<.01$

Girls Posttest: $M_{Exp} = 9.77$, $M_{Ctrl} = 5.27$; $t = 6.37$, $p<.01$

Finding the solution –

Total Posttest: $M_{Exp} = 8.18$, $M_{Ctrl} = 4.24$; $t = 8.67$, $p<.01$

Boys Posttest: $M_{Exp} = 8.00$, $M_{Ctrl} = 4.74$; $t = 4.81$, $p<.01$

Girls Posttest: $M_{Exp} = 8.31$, $M_{Ctrl} = 3.20$; $t = 8.38$, $p<.01$

Total –

Total Posttest: $M_{Exp} = 42.14$, $M_{Ctrl} = 22.39$; $t = 11.78$, $p<.01$

Boys Posttest: $M_{Exp} = 41.33$, $M_{Ctrl} = 23.10$; $t = 6.76$, $p<.01$

Girls Posttest: $M_{Exp} = 42.69$, $M_{Ctrl} = 20.93$; $t = 10.46$, $p<.01$

The mean gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of secondary school students belonging to experimental group are greater than the corresponding gain scores of the control group for Total sample, subsample Boys and subsample Girls. The differences between the mean gain scores of experimental and control groups on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total)are significant for Total sample, sub sample Boys and sub sample Girls.

Understanding the problem-

Total Gain Score: $M_{Exp} = 5.73$, $M_{Ctrl} = 1.04$; $t = 10.77$, $p<.01$

Boys Gain Score: $M_{Exp} = 6.44$, $M_{Ctrl} = 1.23$; $t = 8.37$, $p<.01$

Girls Gain Score: $M_{Exp} = 5.23$, $M_{Ctrl} = 0.67$; $t = 7.23$, $p<.01$

Mapping the problem –

Total Gain Score: $M_{Exp} = 7.11$, $M_{Ctrl} = 0.98$; $t = 11.99$, $p<.01$

Boys Gain Score: $M_{Exp} = 8.56$, $M_{Ctrl} = 0.81$; $t = 11.22$, $p<.01$

Girls Gain Score: $M_{Exp} = 6.12$, $M_{Ctrl} = 1.33$; $t = 6.58$, $p<.01$

Identifying relationships –

Total Gain Score: $M_{Exp} = 5.05$, $M_{Ctrl} = 0.78$; $t = 9.04$, $p<.01$

Boys Gain Score: $M_{Exp} = 6.33$, $M_{Ctrl} = 0.71$; $t = 8.16$, $p<.01$

Girls Gain Score: $M_{Exp} = 4.15$, $M_{Ctrl} = 0.93$; $t = 5.35$, $p<.01$

Finding the solution –

Total Gain Score: $M_{Exp} = 3.43$, $M_{Ctrl} = 0.54$; $t = 6.46$, $p<.01$

Boys Gain Score: $M_{Exp} = 4.50$, $M_{Ctrl} = 0.81$; $t = 5.85$, $p<.01$

Girls Gain Score: $M_{Exp} = 2.69$, $M_{Ctrl} = 0.45$; $t = 4.36$, $p<.01$

Total –

Total Gain Score: $M_{Exp} = 21.32$, $M_{Ctrl} = 3.35$; $t = 12.83$, $p<.01$

Boys Gain Score: $M_{Exp} = 25.83$, $M_{Ctrl} = 3.55$; $t = 11.35$, $p<.01$

Girls Gain Score: $M_{Exp} = 18.19$, $M_{Ctrl} = 2.93$; $t = 8.50$, $p<.01$

Hence Virtual Learning Environment using Geogebra is more effective in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) than conventional method of teaching for Total sample, subsample Boys and subsample Girls.

The results of ANCOVA carried out on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) by taking Nonverbal Intelligence as covariate and the results of Bonferroni's test of post hoc comparison are condensed in Table 40

Table 40

Summary of ANCOVA of Gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) for Total sample, subsample Boys and subsample Girls

Sample	Variable	ANCOVA F	Post Hoc Comparison			Partial eta squared
			Adjusted Means		t-value	
			Experimental Group	Control Group		
Total Sample	Understanding the problem	115.77	5.73	1.04	10.76	.571
	Mapping the problem	142.69	7.11	0.98	11.95	.621
	Identifying relationships	83.08	5.04	0.78	9.12	.488
	Finding the solution	43.23	3.43	0.55	6.58	.332
	Total	168.03	21.31	3.35	12.96	.659
Subsample Boys	Understanding the problem	47.92	6.51	1.18	8.51	.620
	Mapping the problem	56.51	8.51	0.83	10.97	.551
	Identifying relationships	23.26	6.39	0.68	8.22	.336
	Finding the solution	29.64	4.54	0.79	5.86	.319
	Total	53.88	25.95	3.48	11.29	.539
Subsample Girls	Understanding the problem	48.94	5.22	0.68	7.00	.563
	Mapping the problem	40.89	6.03	1.48	6.40	.518
	Identifying relationships	26.39	4.08	1.06	5.14	.410
	Finding the solution	17.51	2.59	0.17	4.18	.315
	Total	72.68	17.93	3.40	8.53	.657

It is evident from Table 40 that all the F values obtained for the effect of Instructional strategy on Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) after controlling the effects of the covariate and the corresponding t values of post hoc comparison of adjusted means of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) are statistically significant for Total sample, subsample Boys and subsample Girls. In all the cases higher values of the adjusted means are associated with the experimental group. The results are substantiated by the values of Partial eta squared also.

Thus from the results of mean difference analysis of pretest scores, posttest scores and gain scores of Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) between experimental and control groups and from the results of ANCOVA and post hoc comparison, it can be concluded that Virtual Learning Environment using Geogebra is more effective than conventional method of teaching in improving Problem solving ability in geometry (Understanding the problem, Mapping the problem, Identifying relationships, Finding the solution and Total) of secondary school students for Total sample, subsample Boys and subsample Girls.

Tenability of Hypotheses

The tenability of the hypotheses of the study was examined on the basis of the findings and is presented in the following sections.

The first hypothesis of the study states that Virtual Learning Environment using Geogebra has significant effect on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender.

Statistically significant difference was found in the mean pretest and posttest scores of Problem Solving Ability (Understanding the Problem) in Geometry of the experimental group for Total sample, subsample Boys and subsample Girls. High mean value is associated with the posttest score.

Hence the first hypothesis is accepted

The second hypothesis of the study states that Virtual Learning Environment using Geogebra has significant effect on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender.

Statistically significant difference was found in the mean pretest and posttest scores of Problem Solving Ability (Mapping the problem) in Geometry of the experimental group for Total sample, subsample Boys and subsample Girls. High mean value is associated with the posttest score.

Hence the second hypothesis is accepted

The third hypothesis of the study states that Virtual Learning Environment using Geogebra has significant effect on ability to Identify Relationships in the problem in Geometry of Secondary School Students for the total group and subgroups based on gender.

Statistically significant difference was found in the mean pretest and posttest scores of Problem Solving Ability (Identifying relationships) in Geometry of the experimental group for Total sample, subsample Boys and subsample Girls. High mean value is associated with the posttest score.

Hence the third hypothesis is accepted

The fourth hypothesis of the study states that Virtual Learning Environment using Geogebra has significant effect on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender.

Statistically significant difference was found in the mean pretest and posttest scores of Problem Solving Ability (Finding the solution) in Geometry of the experimental group for Total sample, subsample Boys and subsample Girls. High mean value is associated with the posttest score.

Hence the fourth hypothesis is accepted

The fifth hypothesis of the study states that Virtual Learning Environment using Geogebra has significant effect on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender.

Statistically significant difference was found in the mean pretest and posttest scores of Problem Solving Ability (Total) in Geometry of the experimental group for Total sample, subsample Boys and subsample Girls. High mean value is associated with the posttest score.

Hence the fifth hypothesis is accepted

The sixth hypothesis of the study states that There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Understand the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Statistically significant difference was found in the adjusted mean gain scores of first component of Problem Solving Ability (Understanding the Problem) between experimental and control groups after controlling the effect of the covariate Non-verbal Intelligence for Total sample, subsample Boys and subsample Girls. High mean value is associated with the experimental group.

Hence the sixth hypothesis is accepted

The seventh hypothesis of the study states that There will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Map the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Statistically significant difference was found in the adjusted mean gain scores of second component of Problem Solving Ability (Mapping the problem) between experimental and control groups after controlling the effect of the covariate Non-verbal Intelligence for Total sample, subsample Boys and subsample Girls. High mean value is associated with the experimental group.

Hence the seventh hypothesis is accepted

The eighth hypothesis of the study states that there will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Identify Relationships in the Problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Statistically significant difference was found in the adjusted mean gain scores of third component of Problem Solving Ability (Identifying relationships) between experimental and control groups after controlling the effect of the covariate Non-verbal Intelligence for Total sample, subsample Boys and subsample Girls. High mean value is associated with the experimental group.

Hence the eighth hypothesis is accepted

The ninth hypothesis of the study states that there will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on ability to Find Solution to the problem in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Statistically significant difference was found in the adjusted mean gain scores of fourth component of Problem Solving Ability (Finding the solution) between experimental and control groups after controlling the effect of the covariate Non-verbal Intelligence for Total sample, subsample Boys and subsample Girls. High mean value is associated with the experimental group.

Hence the ninth hypothesis is accepted

The tenth hypothesis of the study states that there will be significant effect of Virtual Learning Environment using Geogebra than the Conventional Instructional Strategy on Problem Solving Ability in Geometry of Secondary School Students for the total group and subgroups based on gender when the influence of Non-Verbal Intelligence is controlled.

Statistically significant difference was found in the adjusted mean gain scores of Problem Solving Ability (Total) between experimental and control groups after controlling the effect of the covariate Non-verbal Intelligence for Total sample, subsample Boys and subsample Girls. High mean value is associated with the experimental group.

Hence the tenth hypothesis is accepted

Conclusion

The study is an attempt to develop an instructional strategy infusing Virtual Learning Environment using Geogebra and to test its effect on Problem Solving Ability in geometry of secondary school students. The present study was carried out in the changed scenario of the new approach in teaching ie. the constructivist approach which itself aimed to develop the higher order thinking skills of the students. So is the arrangement and presentation of the content in the text book as well. Thus the instructional strategy, Virtual Learning Environment in Geometry developed by the investigator using Geogebra as the major element was compared against the Conventional Instructional Strategy presently practiced in schools of Kerala state.

The initial level of the experimental and control groups in Problem Solving Ability in Geometry are found to be the same. The mean gain scores on Problem Solving Ability of experimental and control groups differ significantly favouring the experimental group after the intervention. The developed Virtual Learning Environment using Geogebra is found to have high effect for improving the Problem Solving Ability in Geometry for total sample and subsamples based on gender. This strongly points outs the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students.

Chapter **6**

RECOMMENDATIONS

- *Educational Implications of the Study*
- *Recommendations for Further Studies*

RECOMMENDATIONS

Higher order thinking skills are becoming must have skills in this competent world for the past many years. Every individual requires a set of skills in order to compete in the era of knowledge revolution. Problem solving is such a skill which have wide application in the entire education realm and in the real life. Technology also have conquered all the spheres of life. Hence education has revolutionized with technology ever before. Enhancement of skills of the century in the technological environment is a matter of concern today. At this juncture the present study has become relevant and significant.

Mathematics has been considered as a harder subject by the student community for the past many decades. Problem Solving Ability is the major skill to develop through Mathematics and to learn mathematics properly. But many of the students are not being well trained with Problem Solving Skills and hence they lag behind in the understanding of Mathematics. Though the conventional method of teaching in the present constructive approach trying to overcome this hurdle, the problem still prevails. This context compelled the investigator to find out a better and meaningful strategy to develop Problem Solving Ability of students. As a solution, the investigator developed a Virtual learning Environment Using Geogebra and tested its effect on Problem Solving Ability in Geometry of secondary school students. The result revealed that Virtual Learning Environment Using Geogebra improved the Problem Solving Ability in Geometry of secondary school students. Also it is found that, VLE fosters PSA than conventional method of teaching.

Educational Implications of the Study

The present study carried out by developing an instructional strategy, Virtual Learning Environment using Geogebra and tested its effect on Problem Solving Ability in Geometry of Secondary School students. Since the study used standardized tools and techniques, adopted adequate sample by using appropriate sampling techniques and followed proper research procedures the findings of the study can be generalized. The study has contributed various findings which are having immense implications. Some of them are the following,

Through this study the investigator tried to find out the effect of Virtual Learning Environment using Geogebra on Problem Solving Ability in Geometry of Secondary School Students. The study revealed that Virtual Learning Environment using GeoGebra significantly improve the Problem Solving Ability in Geometry of Secondary School Students better than the Conventional Instructional Strategy.

Findings of the study reveals that, Problem Solving Ability in geometry of both boys and girls are being enriched when learned with Virtual learning Environment using Geogebra than conventional method of teaching. So, the Instructional strategy, Virtual Learning Environment using Geogebra can foster Problem Solving Ability of all the students of Geometry in Secondary School irrespective of gender.

Problem Solving Ability of students' who have under gone the Instructional strategy Virtual Learning Environment was excellent in all components of the Problem Solving Ability (Viz. Understanding the problem, Mapping the problem, Identifying relationships and finding solution to the problem), than those students who were taught with conventional method. This shows that, the instructional strategy, Virtual Learning Environment using Geogebra promotes strong understanding of the concept and enriches each sub skills of Problem Solving Ability of the learner. So, developing and implementing such Virtual Learning Environments in the present education system enhances the Problem Solving Ability of the learner at a high rate.

Various Virtual Learning Environments may be developed without imbibing Problem solving Approach too and they may not enhance Problem Solving Ability.

When a Virtual Learning Environment is developed using Geogebra, with its special features like interactive nature, 3D view, construction and other tools etc. it provides better opportunity for the development of Problem Solving Ability in learners.

Abilities or skills represented by the components of the Problem Solving Ability are to be infused in the regular academic activities and learning experiences followed in the classroom teaching learning process. Different problems may require different thinking strategies and various skills towards the solution of the problem. So creating or facilitating various problem solving environments are the key step in fostering Problem Solving Ability. So efforts are to be made to develop a problem solving approach in the teaching learning process.

It has been proved that, Virtual Learning Environment using Geogebra is highly effective in enhancing Problem Solving Ability in Geometry of Secondary school students. Based on this study we can say that Virtual Learning Environment will be highly beneficial for the learners. So Virtual Learning Environment using any other interactive softwares like Geogebra may also be effective. It may be used instead of conventional method or supplementary to conventional method.

Since Virtual Learning Environments, substitute the conventional classroom up to an extent and improves the logical and problem solving skills at a higher level, space may be provided for such platforms in the school curriculum framework.

As Virtual Learning Environment using Geogebra significantly fosters problem Solving Ability in Geometry of secondary school students, initiation may be taken to train teachers of secondary schools to develop such instructional strategies and to apply the same in supplement of the regular classroom or in a blended mode.

Traditional chalk and talk method of geometry may be supplemented with customized interactive Virtual Learning Environments which provide multidimensional comprehension.

Initiation may be taken to incorporate teaching strategies to promote cognitive skills other than Problem Solving Ability in classrooms irrespective of Virtual Learning Environment or Conventional Instructional Strategy.

Since leaning with VLE cut short the learning time and reduces the complexities in understanding, Short Learning Objects that can be used in Virtual Learning Environments should be developed and made available in the public domain which can be used by all teachers and students anywhere anytime.

Outcome of the current study throws light in to the higher response to digital experiences in the teaching-learning of geometry. This shows the need for bringing similar digital experiences in other topics of Mathematics too.

Recommendations for Further Studies

Though the present study the investigator attempts to enter into the wide arena of integrating Mathematics teaching and learning with Virtual Learning Environment, which have wider acceptance around the globe. Here the investigator developed a Virtual Learning Environment using Geogebra and tested its effect on Problem Solving Ability in geometry of secondary school students. The current study opens door to the conduct of many studies in this area. Only a few number of studies that can be carried out in this field are suggested below.

- The present study is delimited to studying the effect of Virtual Learning Environment only on Problem Solving Ability in Geometry of secondary of School students. Effect of Virtual Learning Environment on other higher order skills such as critical thinking may be studied in future.
- The present study is confined to the development of a Virtual Learning Environment using Geogebra as a major element of the instructional strategy and then tested its effect on Problem Solving Ability in geometry of

secondary school students. There are many applications like Dr. Geo, Kig, etc. which give concrete experiences in Mathematics teaching learning. Development of such a Virtual Learning Environments by integrating other applications and multimedia elements can be done and its effect may be tested in future studies.

- The present study is confined only to secondary school students. Virtual Learning Environments can be developed for Higher secondary school students too and tested for its effect on Problem Solving Ability.
- Virtual Learning Environments on Physics or other science subjects may be developed and its effect on Problem Solving Ability may be tested.
- Studies may be conducted to design, develop and validate various instructional strategies using LMS like Moodle which can enhance Problem Solving Ability of learners.
- Studies can be conducted to design and develop and validate various instructional strategies which can enhance Problem Solving Ability of learners.
- Studies can be carried out to test the effectiveness of Virtual Learning Environments or similar multimedia instructional packages on Problem Solving Ability and achievement in Mathematics of the differently abled students.
- Difference in the effect of the Virtual Learning Environment using Geogebra on Problem Solving Ability can be studied when the content delivery is made in face to face mode and in online mode.
- Case studies of major Virtual Learning Environments enhancing Problem Solving Ability in Mathematics can be carried out.
- Provisions for creation of learning experiences using Virtual Learning Environments like Geogebra may be provided for prospective teachers and a

study may conducted to check whether improvement in comprehension of Problem solving process occur through creation of such learning experiences

- Studies may be conducted on the attitude of Mathematics teachers towards the development and application of Virtual Learning Environments and similar multimedia instructional strategies to develop higher order thinking skills in Mathematics.
- Effect of various problem solving learning environments or problem solving approaches on enhancing Problem Solving Ability may be studied.
- Effect of various problem solving learning environments like schema based instructions, Polya’s model, etc. on enhancing Problem Solving Ability may be studied.

REFERENCES

REFERENCES

Abdelfatah, H. (2010). *Improving attitudes towards geometric proof through a suggested story-based dynamic geometry approach* [Doctoral dissertation, University of Education Karlsruhe]. https://phka.bsz-bw.de/files/3/hussein_abdelfatah.pdf

Adams, N. B. (2017). The knowledge development model: Responding to the changing landscape of learning in virtual environments. *International Association for Development of the Information Society*. https://eric.ed.gov/?id=ED579456

Adeyemo, S. A. (2010). Students ability level and their competence in problem solving task in physics. *International Journal of Educational Research and Technology*, *1*(2), 35-47.

Aggarwal, J. C. (1966). *Educational research: An introduction*. Arya Book Depot.

Akkaya, A., Tatar, E., & Kagizmanli, T.B. (2011). Using dynamic software in teaching of the symmetry in analytic Geometry: The case of GeoGebra. *Procedia Social and Behavioral Sciences, 15*, 2540–2544. https://doi.org/10.1016/ j.sbspro.2011.04.141

Allen, W. C. (2006). Overview and evolution of the ADDIE training system. *Advances in Developing Human Resources*, *8* (4), 430-441. https://doi.org/10.1177%2F152 3422306292942

Alves, F. R. V. (2014). Visualizing the behavior of infinite series and complex power series with the geogebra. *Academia.edu.* https://www.academia.edu/5241092/visualizing _the_behavior_of_infinite_series_and_complex_power_series_with_the_ge ogebra

Alves, P., & Miranda, L. (2017). The influence of virtual learning environments in students' performance. *Universal Journal of Educational Research, 5*(3), 517-527.

Anderson, D. N. (1963). *An experimental evaluation of two methods for developing creative problem-solving abilities in an industrial arts course*. University of Minnesota.

Anderson, J.R. (1980). *Cognitive psychology and its implications*. Freeman

Anderson, J.R. (1980). *Cognitive skill and their acquisition*. Lawrence Erlbaum Associates, Publishers.

Annansingh, F. (2019). Mind the gap: Cognitive active learning in virtual learning environment perception of instructors and students. *Education and Information Technologies*, *24*(6), 3669-3688.

Arenberg, D. (1968). Concept problem solving in young and old adults. *Journal of Gerontology*, *23*(3), 279-282.

Arkün, S., & Akkoyunlu, B. (2008). A study on the development process of a multimedia learning environment according to the ADDIE model and students' opinions of the multimedia learning environment. *Interactive Educational Multimedia*, 17, 1-19. https://revistes.ub.edu/index.php/IEM/article/view/11902

Arvanitaki, M., & Zaranis, N. (2020). The use of ICT in teaching geometry in primary school. *Journal Articles Education and Information Technologies, 25*(6), 5003-5016.

Atebe, H. U. (2008). *Student's van Hiele levels of geometric thought and conception in plane geometry: A collective case study of Nigeria and South Africa* [Doctoral dissertation, Rhodes University].

Aydos, M. (2015). *The impact of teaching mathematics with Geogebra on the conceptual understanding of limits and continuity: The case of Turkish gifted and talented students* [Doctoral dissertation, Bilkent Universitesi, Turkey].

Bakar, K. A., Ayub, A. F. M., & Mahmud, R. (2015). Effects of geogebra towards students' Mathematics performance. *Proceedings of the 7th International Conference on Research and Education in Mathematics: Empowering Mathematical Sciences through Research and Education,* 180-183. https://doi.org/10.1109/ICREM.2015.7357049

Bakar, K. A., Ayub, A. F. M., Tarmizi, R. A., & Luan, W. S. (2015). Effect of teaching mathematics using GeoGebra on students' with dissimilar spatial visualisation. In *AIP Conference Proceedings* (Vol. 1682, No. 1, p. 030006). AIP Publishing LLC.

Banerjee, R. K. (2011). *Student qualities needed for going to grad school*. http://www.brighthub.com/education/postgraduate/articles/103 356.aspx

Barak, M. (2010). Motivating self-regulated learning in technology education. *International Journal of Technology and Design Education*, *20*(4), 381-401.

Barr, H., Gower, B., & Clayton, J. (2007). Faculty response to the implementation of an open source learning management system in three tertiary institutions in New Zealand. *Computers in the Schools*, *24*(3-4), 125-137.

Baykul, Y. (2005). İlköğretimde matematik öğretimi. In H. Serin (Ed.) (2018). Perspectives on the teaching of geometry: Teaching and learning methods. *Journal of Education and Training, 5*(1).

Bayram, S. (2004). *The effect on instruction with concrete models on eighth grade students' geometry achievement and attitudes toward geometry* [Master's thesis, Middle East Technical University].

Bedell, R.C. (1934). The relationship between the ability to recalland the ability to invert in specific learning situations. *Science Education, 18*.

Best, J.W., & Khan, J. V. (2010). *Research in education* (10th ed.). Prentice Hall of India Pvt. Ltd.

Bhagat, K.K., & Chang, C. Y. (2015). Incorporating geogebra into geometry learning-A lesson from India. *Eurasia Journal of Mathematics, Science & Technology Education, 11*(1), 77-86. https://www.academia.edu/10729437/Incorporating_GeoGebra_into_Geometr y_learning-A_lesson_from_India

Billings, M.L. (1934). Problem solving indifferent fields of endeavour. *American Journal of Psychology, 46.*

Borba, M. C., Chiari, A. S. D. S., & de Almeida, H. R. F. L. (2018). Interactions in virtual learning environments: New roles for digital technology. *Educational Studies in Mathematics*, *98*(3), 269-286.

Brad, A. (2011). A study of the problem solving activity in high school students: Strategies and self-regulated learning. *Acta Didactica Napocensia*, *4*(1), 21-30.

Branson, R. K., Rayner, G. T., Cox, J. L., Furman, J. P., King, F. J., & Hannum, W. H. (1975). Interservice procedures for instructional systems development (Phases I, II, III, IV, V, and Executive Summary). *US Army Training and Doctrine Command Pamphlet*, *350*. https://apps.dtic.mil/dtic/tr/fulltext/u2/a019486.pdf

Britain, S., & Liber, O. (2004). *A framework for the pedagogical evaluation of virtual learning environments.* Report 41, JISC Technology Applications Programme. [Online], 10-1-2005, http://www.cetis.ac.uk/members/pedagogy/files/4thMeet_ framework VLE full Report

Brown, J. D. (1996). *Testing in language programs*. Upper Saddle River

Bu, L., Mumba, F., Henson, H., Wright, M., & Alghazo, Y. (2010). *GeoGebra- integrated professional development: The experience of rural in-service elementary (k-8) teachers.* Paper presented at the First North American GeoGebra Conference, Ithaca, New York. http://geogebraithaca.wikispaces.com/file/view/z10_os1-1-1.pdf

Budai, L. (2011, January). GeoGebra in fifth grade elementary mathematics at rural schools. In *Annales Mathematicae et Informaticae, 38*(1), 129-136.

Bulut, M., & Bulut, N. (2011). Pre service teachers' usage of dynamic mathematics software. *The Turkish Online Journal of Educational Technology*, *10*(4).

Burger, A. L., & Jacobson, N. S. (1979). The relationship between sex role characteristics, couple satisfaction and couple problem-solving skills. *American Journal of Family Therapy*, *7*(4), 52-60.

Burke, R.J. (1965). Sex differences in recognizing the correct answer to a problem. *Psychological Report, 17*.

Chacon, I. M. G. (2013). Prospective teachers' interactive visualization and affect in mathematical problem-solving. *The Mathematics Enthusiast*, *10* (1).

Chacon, I.M.G (2011). Mathematics attitudes in computerized environments: A proposal using GeoGebra. In *Model-Centered Learning* (pp. 145-168). Brill.

Chen, C.H. (2010). Computers and education. *Journal Reports, 55*.

Chitra, C.S. (2014). *Efficacy of multimedia package for learning solid geometry at secondary school level*. http://hdl.handle.net/10603/99591

Choi, J., & Walters, A. (2017). Does self-reflection matter for math performance in a virtual learning environment?. *AERA Online Paper Repository*.

Choi, K. S. (2009). *A brief introduction of mathematics education using Geogebra in Korea.* Paper presented at the First International GeoGebra Conference, Austria. http://ggbconference2009.pbworks.com/f/geogebra2009_submission_19.pdf

Choi, K. S. (2010). Motivating students in learning mathematics with GeoGebra. *Annals Computer Science Series*, *8*(2), 65-76.

Chrysanthou, I. (2008). *The use of ICT in primary mathematics in Cyprus: The case of GeoGebra* [Master's thesis, University of Cambridge]. https://archive.geogebra.org/static/publications/2008-Chrysanthou-ICT- Primary-GeoGebra.pdf

Clark, R. C., & Amp., Mayer, R. E. (2008). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. Pfeiffer.

Coelho, A., & Cabrita, I. (2014). A creative approach to isometries integrating geogebra and Italc with 'Paper and Pencil' environments. *Journal of the European Teacher Education Network, 10*, 71-85. https://www.researchgate.net/publication/306032614_A_creative_approach_to

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education* (5th ed.). Routledge Falmer http://dx.doi.org/10.4324/9780203224342

Collis, B. (1997). *Tele-learning in a digital world: The future of distance learning*. International Thomson Computer Press.

Comit. (1975). *History of virtual learning environments* https://no.abcdef.wiki/wiki/History_of_virtual_learning_environments

Cooper, T. (2014). Building dynamic fraction bar models with geogebra. *North American GeoGebra Journal, 3*(1). http://www.geogebrajournal.com/index.php/ggbj/ article/view/54

Cruz, A. M. M., & Contreras, J. N. (2014). The parabola as the locus of the product of two lines: building functions from functions. *North American GeoGebra Journal, 3*(1). http://www.geogebrajournal.com/index.php/ggbj/article/view/48/45

Csapo, B., & Funke, J. (2017). *The nature of problem solving: Using research to inspire 21st century learning*. OECD Publishing.

Dash, M. (1998). *Educational psychology*. Deep and Deep Publications.

Davis, A. L. (2013). Using instructional design principles to develop effective information literacy instruction: The ADDIE model. *College & Research Libraries News*, *74* (4), 205-207. http://crln.acrl.org/index.php/crlnews/article/view/8934/9656

Davoodi, K. (2009). *Investigating learning mathematics using dynamic software: A case study of understanding the concept of slope* [Master's thesis, University of London].

Dayag, J. D. (2018). EFL virtual learning environments: Perception, concerns and challenges. *Teaching English with Technology*, *18*(4), 20-33.

Demirer, V., & Erbas, C. (2016). Trends in studies on virtual learning environments in Turkey between 1996-2014 Years: A content analysis. *Turkish Online Journal of Distance Education*, *17*(4).

Develi, H. M., & Orbay, K. (2003). *İlköğretimde niçin ve nasil bir geometri öğretimi.* Milli

Ding, L., & Jones, K. (2007). Using the van Hiele theory to analyse the teaching of geometrical proof at grade 8 in Shanghai, China.

Dommett, E. J. (2019). Understanding student use of twitter and online forums in higher education. *Education and Information Technologies*, *24*(1), 325-343.

Duatepe, A. (2004). The effects of drama based instruction on seventh grade students' geometry achievement, van Hiele geometric thinking levels, attitude toward mathematics and geometry [Unpublished Doctoral Thesis]. Middle East Technical University, Ankara.

Dutt, S. (1989). The effect of problem solving strategies on the problem solving ability in science of high school students in relation to anxiety level, cognitive styles and intelligence. In *The Fifth Survey of Educational Research* (Vol. 2). NCERT.

Dutta, A. (1990). Learning disabilities in the students in geometry–diagnosis and prevention. In *The Fifth Survey of Educational Research* (Vol. 2). NCERT.

Ebel, R.L., & Frisbie, D.A. (1991). *Essential of educational measurement (5th ed.)*. Prentice-Hall.

Elliot, A.J. (1999). Approach and avoidance motivation and achievement goals. *Educational Psychologist*, *34*(3), 169-189.

Engelbart, D. C. (1962). *Augmenting human intellect: A conceptual framework*. Menlo Park. https://doi.org/10.21236/ad0289565

Enjelvin, G., & Sutton, A. (2004). Let's ask the students for a change. Investigating student learning approaches to, and perceived gains from VLE-novation. *UCN Working Papers Series, 1*.

Entwistle, N. (1992). *The impact of teaching on learning outcomes in higher education: A literature review.* Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, Universities, Staff Development Unit (CVCP-USDU).

Erkoc, M. F., Gecu, Z., & Erkoc, C. (2013). The effects of using Google sketchup on the mental rotation skills of eighth grade students. *Educational Sciences: Theory and Practice*, *13*(2), 1285-1294.

Escuder, A., & Furner, J. M. (2011). The impact of geogebra in math teachers' professional development. *Electronic Proceedings of the Twenty-third Annual International Conference on Technology in Collegiate Mathematics*. http://archives.math.utk.edu/ICTCM/i/23/S113.html

Farooq, S., & Benade, L. (2019). Constructing a dialogic pedagogy in virtual learning environments: A literature review. *New Zealand Journal of Teachers' Work, 16*(1&2), 7-13.

Fidan, N. (1986). Okulda öğrenme ve öğretme. Kadıoğlu Matbaası. In H. Serin (Ed.) (2018). Perspectives on the teaching of geometry: Teaching and learning methods. *Journal of Education and Training, 5*(1).

Fransson, A. (1977). On qualitative differences in learning. IV - Effectives of motivation and test anxiety on process and outcome. *British Journal of Educational Psychology, 47*, 244- 257.

Furner, J. M., & Marinas, C. A. (2013). Learning math concepts in your environment using photography and GeoGebra. *Electronic proceedings of the twenty-fifth annual international conference on technology in collegiate mathematics*. http://archives.math.utk.edu/ICTCM/i/25/S125.html

Furner, J. M., & Marinas, C. A. (2016). Mathematics anxiety in society: A real phenomena and a real solution. *Transformations*, *1*(1). http://nsuworks.nova.edu/transformations/vol1/iss1/3

Gagne, R. M. (1976). The learning basis of teaching methods. *Teachers College Record*, *77*(5), 21-43.

Gagne, R.M. (1965). *The conditions of learning.* Holt, Rinehart.

Garofalo, J., & Lester, F. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal for Research in Mathematics Education, 16*, 163-176.

Gibbs, G. (1999). Learning to learn in a virtual learning environment for philosophy. *Journal of Computer Assisted Learning, 15*(3), 221-231.

Gok, T. (2015). An investigation of students' performance after peer instruction with stepwise problem-solving strategies. *International Journal of Science and Mathematics Education*, *13*(3), 561-582.

Gómez-Chacón, I. M. (2011). Mathematics attitudes in computerized environments: A proposal using GeoGebra. In L. Bu & R. Schoen (Eds.), *Model-centered learning: Pathways to mathematical understanding using GeoGebra* (pp. 145-168). Sense Publishers.

Government of Meghalaya. (2010). *Enrollment statistics of higher secondary students in Shillong*. GoI, Office of the Inspector of Schools.

Granberg, C., & Olsson, J. (2015). ICT-supported problem solving and collaborative creative reasoning: Exploring linear functions using dynamic mathematics software. *The Journal of Mathematical Behavior, 37*, 48-62. https://doi.org/10.1016/j.jmathb.2014.11.001

Green, D. R., & Robinson, C. L. (2009). Introducing geogebra to foundation year students. *MSOR Connections, 9*(2). https://www.heacademy.ac.uk/system/files/msor.9.2c.pdf

Gülseçen, S., Kararaş, E., & Koçoğlu, F. (2012). Can geogebra make easier the understanding of cartesian coordinates? A quantitative study in Turkey. *International Journal on New Trends in Education and Their Implications*, *3*(4), 19-29.

Guncaga, J., & Majherova, J. (2012). GeoGebra as a motivational tool for teaching and learning in Slovakia. *North American GeoGebra Journal, 1*(1). https://ggijro.files.wordpress.com/2011/07/6geogebraguncaga1507antohe.pdf

Gursoy, A. (2006) *Education programs and teaching*. University Bookstore Publications, Gozdem Offset.

Guven, B., & Kosa, T. (2008). The effect of dynamic geometry software on student mathematics teachers' spatial visualization skills. *The Turkish Online Journal of Educational, 7*(4). http://tojet.net/articles/v7i4/7411.pdf

Halat, E. (2006). Sex-related differences in the acquisition of the van Hiele levels and motivation in learning geometry. *Asia Pacific Education Review*, *7*(2), 173-183.

Haralambos, M., & Holborn, M. (2000). *Themes and perspectives*. Collins Educational.

Harlow, H. F. (1959). The development of learning in the rhesus monkey. *American Scientist*, *47*, 459-479.

Hautz, S. (2013). How does a computer enhance mathematical creativity? *Turkish Journal of Research*, *9*(11), 37-43.

Havering. (1970). *History of virtual learning environments*. https://en.wikipedia.org/wiki/History_of_virtual_learning_environments

Hazari, S., & Thompson, S. (2015). Investigating factors affecting group processes in virtual learning environments. *Business and Professional Communication Quarterly*, *78*(1), 33-54.

Henderson, E. M. (1988). *Preservice secondary mathematics teachers' geometric thinking and their flexibility in teaching geometry* [Doctoral dissertation, University of Georgia].

Hohenwarter, J., Hohenwarter, M., & Lavicza, Z. (2010). Evaluating difficulty levels of dynamic geometry software tools to enhance teachers' professional development. *International Journal for Technology in Mathematics Education, 17*(3). https://archive.geogebra.org/en/upload/files/GG_support/Hohenwarter-HW-Lavicza-IJTME.pdf

Hohenwarter, M., Hohenwarter, J., Kreis, Y., & Lavicza, Z. (2008). Mathematics teacher development and technology: Towards an international geogebra institute. In D. Kuchemann (Ed.), *Proceedings of the British Society for Research into Learning Mathematics, 27*(3), 49-54.

Hohenwarter, M., Jarvis, D., & Lavicza, Z. (2009). Linking geometry, algebra, and mathematics teachers: Geogebra software and the establishment of the international geogebra institute. *International Journal for Technology in Mathematics Education, 16*(2).

Hohenwarter, M., Preiner, J., & Yi, T. (2007, July). Incorporating GeoGebra into teaching mathematics at the college level. In *Proceedings of the International Conference for Technology in Collegiate Mathematics 2007*.

Hoskins, S., & vanHooff, J. C. (2005).Web-based learning: Predictors of student use and achievement. *British Journal of Educational Technology, 36*, 177-192.

Hutkemri., & Zakaria, E. (2012). The effect of Geogebra on students' conceptual and procedural knowledge of function. *Indian Journal of Science and Technology*, *5* (12). http://www.indjst.org/index.php/indjst/article/view/30616

Hwang, G. J., Wu, P. H., & Chen, C. C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education*, *59*(4), 1246-1256.

Idris, N. (2009). The impact of using Geometers' Sketchpad on Malaysian students' achievement and van Hiele geometric thinking. *Journal of Mathematics Education*, *2*(2), 94-107.

Jacobson, C., & Lehrer, R. (2000). Teacher appropriation and student learning of geometry through design. *Journal for Research in Mathematics Education*, *31*(1), 71-88.

Jelfs, A., & Colbourn, C. (2002). Virtual seminars and their impact on the role of the teaching staff. *Computers and Education, 38*, 127-136.

Jenkins, M., Browne, T., & Armitage, S. (2001). *Management and implementation of virtual learning environments: Report*. UCISA. http://www.ucisa.ac.uk/TLIG/vle

Jerome, E.A. (1962). *Decay of heuristic process in the aged.* In C. Tibbits & W. Donahue (Eds.), *Social and Psychological aspects of aging*. Columbia University Press.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development*, *48*(4), 63-85.

Jonassen, D. H. (2004). *Learning to solve problems: An instructional design guide.* https://www.pdfdrive.com/learning-to-solve-problems-aninstructional-design-guide-d18930675.html

Jonassen, D. H. (2010). *Learning to solve problems: A handbook for designing problem-solving learning environments*. Routledge.

Joolingen, W. V. (1999). Cognitive tools for discovery learning. *International Journal of Artificial Intelligence in Education, 10,* 385 – 397.

Kagizmanli, T. B., Tatar, E., & Akkaya, A. (2011). Analytic analysis of lines with dynamic mathematical software. *Procedia Social and Behavioral Sciences, 15*, 2505–2509. https://doi.org/10.1016/j.sbspro.2011.04.136

Karadag, Z., & McDougall, D. (2008). E-contests in mathematics: Technological challenges versus technological innovations. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications,* 6331-6336.

Khlaisang, J., & Songkram, N. (2019). Designing a virtual learning environment system for teaching twenty-first century skills to higher education students in ASEAN. *Technology, Knowledge and Learning*, *24*(1), 41-63.

Khorshidi, A., & Peterson, A. A. (2016). Amp: A modular approach to machine learning in atomistic simulations. *Computer Physics Communications*, *207*, 310-324.

Konrad, J. (2003). *Review of educational research on virtual learning environments [VLE] - implications for the improvement of teaching and learning and access to formal learning in Europe*. Paper presented at the European Conference on Educational Research, University of Hamburg, 17-20 September.

Koul, L. (1997). *Methodology of Educational Research*. Vikas

Krishnan, N.J. (1990). The identification of problem solving strategies in maths among high school students in Devakottai educational district [M.Phil. Education, Alagappa University]. *The 5th Survey of Educational Research, 2, NCERT,* 1988-92.

Kucukahmet, L. (1998). *Principles and methods of teaching.* Alkum Publications.

Kumar, D. (1979). An experimental study of problem solving behaviour as function of personality drive and practice [Unpublished doctoral dissertation, Punjab University]. In *The Fifth Survey of Educational Research* (Vol. 2). NCERT.

Kumar, D. (1980). The role of motivating instructions in insightfulproblem solving in males and females. *Psychologia.*

Kumari, V. (1991). Problem solving strategies and cognitive capabilities of children of age-group 10-12. *Indian Education Review*, 24-27.

Kundu, C.L., & Tutoo, D.N. (2008). *Educational psychology*. Sterling Publishers Private Limited.

Kurtulus, A., & Uygan, C. (2010). The effects of google sketchup based geometry activities and projects on spatial visualization ability of student mathematics teachers. *Procedia Social and Behavioral Sciences, 9*, 384–389. https://doi.org/10.1016/j.sbspro.2010.12.169

Kushwaha, R. C., Chaurasia P. K., & Singhal, A. (2014). Impact on students' achievement in teaching mathematics using geogebra. *Proceedings of the IEEE Sixth International Conference on Technology for Education,* 134-137. https://doi.org/10.1109/T4E.2014.54

Lakshmi, A. R., & Arora, M. (2006). Perceived parental behaviour as related to student's academic school success and competence. *Journal of the Indian Academy of Applied Psychology*.

Lamm, A. J., Shoulders, C., Roberts, T. G., Irani, T. A., Snyder, L. J. U., & Brendemuhl, J. (2012). The influence of cognitive diversity on group problem solving strategy. *Journal of Agricultural Education*, *53*(1), 18-30.

Larkin, J. (1981). Understanding problem solving in physics. In J. Robinson (Ed.), *Research in science and education: New questions, new directions*. Centre for Educational Research and Evaluation.

Lavicza, Z., & Varga, Z. P. (2010). Integrating GeoGebra into IWB- equipped teaching environments: Preliminary results. *Technology, Pedagogy and Education, 19*(2), 245-252. https://doi.org/10.1080/1475939X.2010.

Laxman, K. (2010). Computers and education. *Journal Articles Report, 55*.

Lester Jr, F. K., & Garofalo, J. (1982). *Mathematical problem solving: Issues in research*. Franklin Institute Press.

Leung, A., & Lee, A. M. S. (2012). Students' geometrical perception on a task-based dynamic geometry platform. *Educational Studies in Mathematics, 82*, 361– 377. http://link.springer.com/article/10.1007/s10649-012-9433-7

Liew, T., Azan-Mat-Zin, N., Sahari, N., & Tan, S. M. (2016). The effects of a pedagogical agent's smiling expression on the learner's emotions and motivation in a virtual learning environment. *International Review of Research in Open and Distributed Learning: IRRODL*, *17*(5), 248-266.

Lingefjard, T., Ghosh, J., & Kanhere, A. (2012). *Students solving investigatory problems in a dynamic geometry environment - A study of students' work in India and Sweden*. Paper presented at the 12th International Congress on Mathematical Education. http://nime.hbcse.tifr.res.in/indian-participants-at-icme-2012/ThomasLJonakiGAalokaK_TSG1913Investigatory problemsingeometricenvironment.pdf

Ljajko, E. (2016). Does the problem complexity impact students' achievements in a computer aided mathematics instruction? *The Teaching of Mathematics, 19*(1).

López, N. R. (2011). GeoGebra workshop for the initial teacher training in primary education. *International Journal for Technology in Mathematics Education*, *18*(4), 183-188.

Luskin, B. J., & Friedland, L. (2014). Task force report: Media psychology and new technologies. *PsycEXTRA Dataset*. https://doi.org/10.1037/e522152014-001

Mainali, B. R. (2014). GeoGebra from students' perspectives. *GeoGebra International Journal of Romania*, *3*(1), 31-38.

Mainali, B. R., & Key, M. B. (2012). Using dynamic geometry software GeoGebra in developing countries: A case study of impressions of mathematics teachers in Nepal. *The Indefinite Accumulation of Finite Amounts: A Socratic Educative Experience, 1*. https://www.learntechlib.org/p/132606

Manchisi. (2021). Grade 11 students' reflections on their Euclidean geometry learning experiences. *Journal Articles, EURASIA Journal of Mathematics ,Science and Technology Education*, *17* (2).

Manoharan, J. L. (2009). Problem solving ability in mathematics of XI standard students in Villupuram District. *Research and Reflections on Education*, *7*(3).

Martins, L. L., & Kellermanns, F. W. (2004). A model of business school students' acceptance of a web-based course management system. *Academy of Management Learning & Education*, *3*(1), 7-26.

Marton, F., & Saljo, R. (1976). On qualitative differences in learning I. Outcome and process. *British Journal of Educational Psychology, 46*, 4-11.

Marton, F., & Saljo, R. (1997). Approaches to learning. In F. Marton, D. Hounsell & N. Entwistle (Eds.). *The experience of learning*. Edinburgh: Scottish Academic Press, 39-58.

Mateya, M. (2008). *Using the Van Hiele theory to analyse geometrical conceptualisation in grade 12 students: A Namibian perspective* [Doctoral dissertation, Rhodes University].

May, W. L. (2013). *The use of geogebra in collaborative learning in mathematics* [Master's thesis, University of Technology, Malaysia]. http://www.fp.utm.my/epusatsumber/pdffail/ptkghdfwP2/Wong%20Lit%20M ay.TP.pdf

Mayfield, M. (2011). Creating training and development programs: Using the ADDIE method. *Development and Learning in Organizations: An International Journal, 25* (3), 19-22. https://doi.org/10.1108/14777281111125363

McNaught, C., & Lam, P. (2005). Building an evaluation culture and evidence base for e-learning in three Hong Kong universities. *British Journal of Educational Technology, 36*(4), 629-642.

Mehanovic, S. (2011). *The potential and challenges of the use of dynamic software in upper secondary mathematics: Students' and teachers' work with integrals in geogebra based environments* [Licentiate thesis, Linkoping University]. http://www.diva-portal.org/smash/get/diva2:421408/FULLTEXT01.pdf

Mehdiyev, R. (2009). *Exploring students' learning experiences when using a Dynamic Geometry Software (DGS) tool in a geometry class at a secondary school in Azerbaijan* [Master's thesis, University of Amsterdam]. https://esc.fnwi.uva.nl/thesis/centraal/files/f907846476.pdf

Mendelsohn, C.A, Grisworld, B.B., & Anderson, M.L. (1966). Individual difference in anagram solving ability. *Psychological Review, 19*.

Miller, D. (2013). Investigating the generalization of a special property of cubic polynomials to higher degree polynomials. *North American GeoGebra Journal, 2*(1). http://www.geogebrajournal.com/index.php/ggbj/article/view/25

Milton, G.A. (1957). The effects of sex role identification upon problem solving skills. *Journal of Abnormal and Social Psychology, 55*.

Mimirinis, M., & Bhattacharya, M. (2007). Design of virtual learning environments for deep learning. *Journal of Interactive Learning Research, 18*. 55-64.

Miyan, M. (1982). A study to examine the effectiveness of methods of teaching maths in developing mathematical creativity [Doctoral dissertation, Jamia Millia Islamia]. In *The Fifth Survey of Educational Research* (Vol. 2). NCERT.

Mogus, A. M., Djurdjevic, I., & Suvak, N. (2012). The impact of student activity in a virtual learning environment on their final mark. *Active Learning in Higher Education*, *13*(3), 177-189.

Morrison, G. R., Ross, S. J., Morrison, J. R., & Kalman, H. K. (2006). *Designing effective instruction (5th ed.)*. Jossey-Bass.

Mukiri, M. I. (2012). *Feasibility of using geogebra in the teaching and learning of geometry concepts in secondary schools in Kajiado County, Kenya* [Doctoral dissertation, Kenyatta University]. http://ir-library.ku.ac.ke/handle/123456789/15094

Murugaiah, P., & Yen, S. H. (2019). Implementing a social media-based curriculum for newly-matched interns. *International Journal of Virtual and Personal Learning Environments*, *9*(2), 4.

Muruganantham, G. (2015). Developing of E-content package by using ADDIE model. *International Journal of Applied Research*, *1* (3), 52-54.

Nash, D.A. (1994). The life-long learning imperative... ends and mean. *Journal of Dental Education*, *58*, 785-790.

Nipharake, A.M. (1977). An experimental study of some methods of training in creativity. University of Poona. *The 5th Survey of Educational Research, 2: NCERT*,1988-92.

Nuzum, M. (1983). *The effects of an instructional model based on the information processing paradigm on the arithmetic problem solving performance of four learning disabled students* [Doctoral dissertation, Teachers College, Columbia University].

Oliver, M. (2000). An introduction to the evaluation of learning technology. *Educational Technology & Society, 3*(4), [Online], http://ifets.ieee.org/periodical/vol_4_2000/intro.html

Olsson, J. (2014). *Dynamic software enhancing creative mathematical reasoning* [Doctoral dissertation, Umeå Universitet].

Pahl, C. (2003). Managing evolution and change in web-based teaching and learning environments. *Computers in Education, 40.* 99-114.

Parnes, S. J., & Meadow, A. (1959). Effects of brainstorming instructions on creative problem solving by trained and untrained subjects. *Journal of Educational Psychology*, *50*(4), 171.

Peker, M., & Halat, E. (2008). The pre-service elementary school teachers' mathematics teaching anxiety and gender. In *The European Conference on Educational Research* (Vol. 10, p. 12).

Pesen, C. (2006). *Matematik Öğretimi (3. Baskı)*. Pegem yayıncılık. In H. Serin (Ed.) (2018). Perspectives on the teaching of geometry: Teaching and learning methods. *Journal of Education and Training, 5* (1).

Piaget, J. (2000). Piaget's theory of cognitive development. *Childhood cognitive development: The essential readings*, *2*, 33-47.

Plato. (1960). Encyclopedia Britannica. https://www.britannica.com/topic/PLATO-education-system

Praveen, M.G. (2014). *Effect of mastery learning strategy on problem solving ability in physics of secondary school students*. http://hdl.handle.net/10603/20949

Praveen, M.G. (2017). *Preparation and validation of a schema based instructional module with MOODLE to foster problem solving ability in physics at higher secondary level* [Post Doctorial thesis, Farook Training College, Research Centre in Education, Calicut, Kerala, India].

Preiner, J. (2008). *Introducing dynamic mathematics software to mathematics teachers: The case of geogebra* [Doctoral dissertation, University of Salzburg]. https://archive.geogebra.org/static/publications/jpreiner-dissertation.pdf

Preiner, J. (2008). *Introducing dynamic mathematics software to mathematics teachers: The case of Geogebra* [Dissertation in mathematics education, Faculty of Natural Sciences, University of Salzburg].

Radović, S., Radojičić, M., Veljković, K., & Marić, M. (2020). Examining the effects of geogebra applets on mathematics learning using interactive mathematics textbook. *Interactive Learning Environments*, *28*(1), 32-49.

Rahman, M. H. A., & Puteh, M. (2016). Learning trigonometry using GeoGebra learning module: Are under achieve pupils motivated?. In *AIP Conference Proceedings* (Vol. 1750, No. 1, p. 040001). AIP Publishing LLC.

Rahman, R. (2016). Effect learning assisted geogebra against creative thinking ability. *Scribd*. https://www.scribd.com/document/296573466/Effect-Learning-Assisted-GeoGebra-Against-Creative-Thinking-Ability

Rai, S. (1982). Problem solving in science of creative and non creative students [Docotoral Thesis, Department of Education, Patna University, 1982]. *The 5th Survey of Educational Research, vol 2: NCERT*, 1988-92.

Ramsden, P., & Entwistle, N. J. (1981). Effects of academic departments on students' approaches to studying. *British Journal of Educational Psychology, 51,* 368-383.

Raven, J.C. (1958). *Standard progressive matrices sets A, B, C, D & E*. M. K. Lewis and Coll Ltd.

Reddy, M. A. (1992). *Teaching of theorems in geometry in secondary schools*. Progress of Education Murthy as cited in Chithra, 2014

Reddy, S. (1993). The development of reasoning and creativity among standard 9 students [M.Phil Education, Annamalai University]. *The 5th Survey of Educational Research, vol 2: NCERT,* 1988-92.

Reis, Z. A. (2010). Computer supported mathematics with geogebra. *Procedia Social and Behavioral Sciences*, *9*, 1449–1455. https://doi.org/10.1016/j.sbspro.

Reis, Z.A., & Gulsecen, S. (2010). *The effect of the geogebra use in mathematics education: A case study on integers in Turkey.* Paper presented at the First North American GeoGebra Conference, Ithaca, NY. Retrieved from https://geogebraithaca.wiki spaces.com/file/view/z10_os3-2-1.pdf

Reisoğlu, I., Topu, B., Yılmaz, R., Karakuş Yılmaz, T., & Göktaş, Y. (2017). 3D virtual learning environments in education: A meta-review. *Asia Pacific Education Review*, *18*(1), 81-100.

Richardson, J. (2001). *An evaluation of virtual learning environments and their learners: Do individual differences affect perception of virtual learning environments*. *Interactive Multimedia, 3*, 38-52. 10-1-2006. http://www.ub.es/multimedia/iem

Roberts, S.K. (2010). Mathematics teaching in the middle school. *Journal Articles, Reports-Descriptive, 16(2).*

Rodrigues, A. (2015). *Mathematics creativity and technology (GeoGebra) in teaching of algebra: A case study of 9th grade of education basic*. Paper presented at the International congress on education, innovation and learning technologies. Retrieved from http://www.scienceknowconferences.com/files/extended_ abstracts/ iceilt2015/?dir=Education

Rosenblatt, F. (1958). The perceptron: A probabilistic model for information storage and organization in the Brain, Cornell Aeronautical Laboratory. *Psychological Review, 65(*6), 386-408.

Rudmann, D. S. (2002). *Solving astronomy problems can be limited by intuited knowledge, spatial ability, or both*. Presented at the annual meeting of the American Educational Research Association. https://files.eric.gov/fulltext/ED468815.pdf

Rumanova, L., & Smieskova, E. (2015). Creativity and motivation for geometric tasks designing in education. *Acta Didactica Napocensia, 8*(1), 49-56. http://padi.psiedu.ubbcluj.ro/adn/article_8_1_6.pdf

Saha , R.A., Ayub, A. F. M., & Tarmizi, R. A. (2010). The effects of geogebra on mathematics achievement: Enlightening coordinate geometry learning. *Procedia Social and Behavioral Sciences*, *8* , 686–693. https://doi.org/10.1016/j. sbspro.

San, I. & Kis, A. (2018). Effect of traditional methods in geometry and numbers learning domains on academic achievement: A Meta-analysis study. *International Journal of Research in Education and Science (IJRES), 4*(2), 544-554. https://doi.org/10.21890/ijres.428950

Santos, M.A., & Netto (2020). Improving learning in virtual learning environment using affective pedagogical agent. *International Journal of Distance Education Technologies, 18*(4), 1-16.

Santos-Trigo, M., Aguilar-Magallón, D., & Reyes-Martínez, I. (2019). A mathematical problem-solving approach based on digital technology affordances to represent, explore, and solve problems via geometric reasoning. In *Problem Solving in Mathematics Instruction and Teacher Professional Development* (pp. 145-166). Springer, Cham.

Scott, E., Soria, A., & Campo, M. (2016). Adaptive 3D virtual learning environments-A review of the literature. *IEEE Transactions on Learning Technologies*, *10*(3), 262-276.

Shadaan, P., & Eu, L. K. (2013). Effectiveness of using geogebra on students' understanding in learning circles. *The Malaysian Online Journal of Educational Technology, 1*(4). http://www.mojet.net/frontend/articles/pdf/v01i04/v01i04-01.pdf

Simonson, M., & Schlosser, L. A. (2006). *Distance education: Definition and glossary of term* (2nd ed.). Information Age Publishing.

Singer, F. M., & Voica, C. (2015). Is problem posing a tool for identifying and developing mathematical creativity?. In *Mathematical problem posing* (pp. 141-174). Springer.

Singh, K.A. (1979). A study of problem solving behaviour as a function of intelligence and extraversion [Unpublished M.Phil dissertation]. Himachal Pradesh University, 1979. In *The 5th Survey of Educational Research* (Vol. 2). NCERT.

Siyepu, S. W. (2005). *The use of Van Hiele's theory to explore problems encountered in circle geometry: A grade 11 case study* [Doctoral dissertation, Rhodes University].

Skinner, B. F. (1968). Teaching science in high school—What is wrong? Scientists have not brought the methods of science to bear on the improvement of instruction. *Science*, *159* (3816), 704-710.

Stanic, G., & Kilpatrick, J. (1989). Historical perspectives on problem solving in the mathematics curriculum. *The Teaching and Assessing of Mathematical Problem Solving*, *3*, 1-22.

Stork, P.A, Looft, W.R., & Hooper, F.H. (1972). Interrelationships among Piagetian tasks and traditional measures ofcognitive abilities in mature and aged adults. *Journal of Gerontology*.

Successmaker. (1980). *History of virtual learning environments.* https://no.abcdef.wiki/wiki/History_of_virtual_learning_environments

Supiandi, M., & Ege, B. (2017). The effect of group investigation (G) learning model on the student problem solving ability and students' academic achievements on the digestive system material for biology students. *Anatolian Journal of Education, 2*(2), 55-65.

Suppes, P. (1972). *Introduction: Computer-assisted instruction at Stanford, 1966-68*, (pp. 1-13). https://doi.org/10.1016/b978-0-12-676856-5.50004-8.

Suppes, P., & Atkinson, R. C. (1960). *Markov learning models for multiperson interactions*. Stanford University Press. https://institute-of-progressive-education-and-learning.org/elearning-i/history-of-elearning/

Tait, H., Entwistle, N. J., & McCune, V. (1998). ASSIST: A reconceptualisation of the approaches to studying inventory. In C. Rust (Ed.), *Improving student learning: Improving students as learners.* Oxford Brookes University.

Tatar, E., & Zengin, Y. (2016). Conceptual understanding of definite integral with geogebra. *Computers in the Schools*, *33*(2). https://doi.org/org/10.1080/07380569.

Triantafyllou, E., & Timcenko, O. (2013). *Using geogebra for mathematics education at university undergraduate level*. Paper presented at the Nordic GeoGebra Conference, Copenhagen, Denmark. http://vbn.aau.dk/en/publications/using-geogebra-for-mathematics-education- at-university-undergraduate-level(74a3a7fd-83e4-457c-9fc7-d8f8d8 b14d7b).html

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Education, 37,* 57-70.

Turgut, M., & Uygan, C. (2015). Designing spatial visualization tasks for middle school students with 3D modelling software: An instrumental approach. *International Journal for Technology in Mathematics Education, 22*(2), 45-51. http://eric.ed.gov/?id=EJ1079194

Turoff, M. (1974). Future applications of computerized conferencing. *Proceedings of the 1974 Annual Conference on XX - ACM '74*. https://doi.org/10.1145/1408800.1408910

Ubuz, B., & Aşkar, P. (1999). Current state of the mathematics education community in Turkey. *Hacettepe University Faculty of Education Journal,* 94-103. https://hdl.handle.net/11511/85156

Udi, E. A., & Radakovic, N. (2012). Teaching probability by using GeoGebra dynamic tool and implementing critical thinking skills. *Procedia - Social and Behavioral Sciences*, *46*, 4943 – 4947. https://doi.org/10.1016/j.sbspro.2012.06.364

Velichova, D. (2011). Interactive Maths with GeoGebra. *International Journal of Emerging Technologies in Learning, 6*(1), 31-35.

Vogel, C., Großer, B., Baumöl, U., & Bastiaens, T. J. (2018). Tacit knowledge in virtual university learning environments. *International Association for Development of the Information Society*.

Walford, A.T. (1958). *Aging and human skill.* OxfordUniversity Press.

Weckbacher, L., & Okamoto, Y. (2018). Predictability of visual process on performance in geometry. *Journal of Education and Learning, 7*(6), 25-36.

Weinhandl, R., Lavicza, Z., Hohenwarter, M., & Schallert, S. (2020). Enhancing flipped mathematics education by utilising GeoGebra. *International Journal of Education in Mathematics, Science and Technology (IJEMST), 8*(1), 1-15.

Woodworth, J., & Marquis, P. (1948). Psychology of adults. *Advanced Educational Psychology*, 121-25.

Yaacob, A. M., Mohamed, M., & Ariffin, W. N. M. (2016). Web based and geometry learning module for Form 4 & 5 using GeoGebra. *Proceedings of the American Institute of Physics Conference*. https://doi.org/10.1063/1.4965210

Yavuz, A., & Cancan, M. (2007). Analysis of student views on problem solving in mathematics teaching. *Journal of Atatürk University Kazım Karabekir Faculty of Education*, *16*, 374-390.

Yazdani, M. A. (2007). Correlation between students' level of understanding geometry according to the vanHieles' Model and students achievement in plane geometry. *Journal of Mathematical Sciences & Mathematics Education*, *2*(2), 40-45.

Yeh, H. C., & Tseng, S. S. (2019). Using the Addie model to nurture the development of teachers' CALL professional knowledge. *Journal of Educational Technology & Society*, *22* (3), 88-100. https://www.jstor.org/stable/26896712

Yildiz, B., & Tuzun, H. (2011). Effects of using three-dimensional virtual environments and concrete manipulatives on spatial ability. *Hacettepe University Journal of Education, 41*, 498-508. https://www.researchgate.net/publication/27976038 4_Effects_of_using_three- dimensional_virtual_environments_and_concrete_mani pulatives_on_spatial_a bility_Ucboyutlu_sanal_ortam_ve_somut_materyal_kullan iminin _uzamsal_ye tenege_etkileri

Yorganic., & Serpil. (2018). A study on the views of graduate students on the use of geogebra in mathematics teaching. *European Journal of Education Studies, 4*(8), 63-78.

Yunus, M, Setyosari, P, Utaya, S, Kuswandi, D, Amirullah, & Rusdi, M. (2021). The relationship between achievement motivation, metacognitive awareness, attitudes, and problem-solving abilities in students. *Cypriot Journal of Educational Science. 16*(1), 32-45. https://doi.org/10.18844/cjes.v16i1.5506

Yunus, M., & Setyosari, P. (2021). The influence online project collaborative learning and achievement motivation on problem solving ability. *European Journal of Educational Research, 10*(2), 813-823.

Yunus, M., Setyosari, P., Utaya, S., Kuswandi, D., Amirullah., & Rusdi, M. (2021). The relationship between achievement motivation, metacognitive awareness, attitudes, and problem-solving abilities in students. *Cypriot Journal of Educational Science, 16*(1), 32-45. https://doi.org/10.18844/cjes.v16i1.5506

Zacharzuk-Marciano, T. (2017). *Nursing faculty experiences of virtual learning environments for teaching clinical reasoning* [Doctoral dissertation, Capella University].

Zakaria, E., & Lee, L.S. (2012). Teachers perceptions toward the use of geogebra in the teaching and learning of mathematics. *Journal of Mathematics and Statistics, 8* (2), 253-257. https://doi.org/10.3844/jmssp.2012.253.257

Zanzali, N. A. A., Abdullah, A. H., Ismail, N., Nordin, A., & Surif, J. (2011). Comprehensive indicators of mathematics understanding among secondary school students. In *Turning Dreams into Reality: Transformations and Paradigm Shifts in Mathematics Education: Proceedings of 11th International Conference, pp. 377-380.* Rhodes University.

Zengin, Y., Furkan, H., & Kutluca, T. (2012). The effect of dynamic mathematics software geogebra on student achievement in teaching of trigonometry. *Procedia-Social and Behavioral Sciences*, *31*, 183-187.

Zetrijuslita., & Endang. (2021). The increasing self efficacy and self-regulated through geogebra based teaching reviewed from initial mathematic ability (IMA) level. *International Journal of Instruction, 14*(1), 587-598.

Zulnaidi, H., & Zakaria, E. (2012). The effect of using geogebra on conceptual and procedural knowledge of high school mathematics students. *Asian Social Science*, *8*(11). https://doi.org/10.5539/ass.v8n11p102

Zwart, D.P., & Goei, S.L. (2021). The effects of computer based virtual learning environment on nursing students' mathematical learning in medication process. *Research and Practice in Technology Enhanced Learning, 16*(1).

APPENDICES

Appendix I

FAROOK TRAINING COLLEGE

Affiliated to University of Calicut

PROBLEM SOLVING ABILITY TEST IN GEOMETRY (2019)

(MALAYALAM- FINAL)

Std: IX Time : 1 ½ hour

Rishad Kolothumthodi
Research Scholar

Dr. Manoj Praveen. G
Associate Professor

നിർദ്ദേശങ്ങൾ

ജ്യാമിതിയുമായി ബന്ധപ്പെട്ട ജീവിതസാഹചര്യങ്ങളിൽ നിന്നുമുള്ള ചില ചോദ്യങ്ങളാണ് താഴെ കൊടുത്തിരിക്കുന്നത്. ഉത്തരത്തിലെത്തുന്നതിനായി ഓരോ ചോദ്യങ്ങൾക്കും 4 വീതം ഉപചോദ്യങ്ങൾ നൽകിയിട്ടുണ്ട്. എല്ലാ ചോദ്യങ്ങൾക്കും അവരവരുടെ യുക്തി അനുസരിച്ചാണ് ഉത്തരം എഴുതേണ്ടത്. എല്ലാ ഉത്തരങ്ങൾക്കും ആവശ്യമായ ചിത്രങ്ങളും കൃത്യമായ വഴികളും ഉണ്ടാകണം.

---

1. സരിൻ, അവൻ നിൽക്കുന്നിടത്ത് നിന്ന് നേരെ 50 മീറ്ററും അവിടെ നിന്ന് വലത്തോട്ട് 30 മീറ്ററും വീണ്ടും വലത്തോട്ട് 50 മീറ്ററും സഞ്ചരിച്ചു. സരിൻ നടത്തം തുടങ്ങിയടത്ത് എത്തണമെങ്കിൽ ഇനി എത്ര ദൂരം സഞ്ചരിക്കണം?
   (a) ഇപ്പോൾ നിൽക്കുന്നിടത്ത് നിന്ന് നടത്തം തുടങ്ങിയടത്ത് എത്തിച്ചേരാൻ എത്ര ദൂരമുണ്ടെന്ന് കണ്ടെത്താൻ തന്നിരിക്കുന്ന സാഹചര്യത്തിൽ നിന്നും ഏതൊക്കെ വിവരങ്ങളാണ് ആവശ്യമായി വരുന്നത്?
   (b) സഞ്ചരിച്ച പാത എങ്ങനെ വരയ്ക്കാം?
   (c) നടത്തം പൂർത്തിയാക്കണമെങ്കിൽ വരച്ചിരിക്കുന്ന പാതയിൽ നോക്കി എത്ര ദൂരം സഞ്ചരിക്കണമെന്ന് എങ്ങനെ കണ്ടെത്താം?
   (d) എങ്കിൽ സരിൻ ഇനി എത്ര മീറ്റർ നടക്കണം?
2. ഒരു ഭൂപടത്തിൽ രണ്ട് സ്ഥലങ്ങൾ രേഖപ്പെടുത്തിയിട്ടുള്ളത് 5 സെന്റിമീറ്റർ അകലത്തിലാണ്. ഭൂപടത്തിന്റെ തോത് 1 സെ.മിക്ക് 10 കി.മീ ആണെങ്കിൽ ആ രണ്ട് സ്ഥലങ്ങൾ തമ്മിലുള്ള യഥാർത്ഥ ദൂരമെത്ര?
   (a) സ്ഥലങ്ങൾ തമ്മിലുള്ള ഭൂപടത്തിലെ അകലത്തിൽ നിന്നും യഥാർത്ഥ അകലം കണ്ടെത്താൻ ഏത് മാർഗ്ഗമാണ് സ്വീകരിക്കേണ്ടത്?
   (b) തന്നിരിക്കുന്ന വിവരങ്ങളെ എങ്ങനെ ചിത്ര രൂപത്തിൽ സൂചിപ്പിക്കാം?
   (c) ഭൂപടത്തിലെ അകലവും യഥാർത്ഥ അകലവും എങ്ങനെ ബന്ധപ്പെട്ടിരിക്കുന്നു?
   (d) എങ്കിൽ സ്ഥലങ്ങൾ തമ്മിലുള്ള യഥാർത്ഥ അകലം എത്രയാണ്?
3. ഒരു സ്വർണ്ണ കമ്പി (Gold rod) വളച്ച് 4 സെന്റിമീറ്റർ വ്യാസമുള്ള ഒരു വളയുണ്ടാക്കി. ഇതിന്റെ പകുതി നീളമുള്ള സ്വർണ്ണക്കമ്പി വളച്ചുണ്ടാക്കുന്ന വളയുടെ വ്യാസമെന്തായിരിക്കും (diameter)?
   (a) എന്താണ് കണ്ടു പിടിക്കേണ്ടത്?
   (b) തന്നിരിക്കുന്ന വിവരങ്ങളുടെ രേഖാചിത്രം വരച്ചു നോക്കൂ?

(c) കമ്പി നേർ പകുതിയാക്കുമ്പോൾ ലഭിക്കുന്ന പുതിയ കമ്പിയുടെ നീളം എന്തായിരിക്കും?

(d) എങ്കിൽ ചെറിയ വളയുടെ വ്യാസമെന്തായിരിക്കും?

4. 10 മീറ്റർ നീളവും 6 മീറ്റർ വീതിയുമുള്ള ഒരു ഹാളിന്റെ തറയിൽ 1 മീറ്റർ നീളവും 50 സെന്റിമീറ്റർ വീതിയുമുള്ള ടൈൽ ഒട്ടിക്കണമെങ്കിൽ എത്ര ടൈൽ വേണ്ടിവരും?

(a) ഹാളിന്റെ തറയിൽ ടൈൽ ഒട്ടിക്കണമെങ്കിൽ ആദ്യം റൂമിന്റെ എന്തളവാണ് കണ്ടു പിടിക്കേണ്ടത്?

(b) ലഭ്യമായ വിവരങ്ങളെ ചിത്ര രൂപത്തിൽ വരക്കാമോ?

(c) ആകെ വേണ്ട ടൈലിന്റെ എണ്ണം അറിയണമെങ്കിൽ ഒരു ടൈലിന്റെ പരപ്പളവ് (area) കാണണമോ? എങ്കിൽ അതെങ്ങനെ കാണാം?

(d) എങ്കിൽആകെ എത്ര ടൈലാണ്ആവശ്യമായിവരുന്നത്?

5. ഒരു ലോറിയിൽ 4 മീറ്റർ നീളത്തിലും രണ്ട് മീറ്റർ വീതിയിലും 1 മീറ്റർ ഉയരത്തിലും മണൽ നിറച്ചിട്ടുണ്ട്. 1 ഘനമീറ്റർ മണലിന് 1000 രൂപയാണ് വിലയെങ്കിൽ ലോറി യിലെ മണലിന്റെ വിലയെത്ര?

(a) ലോറിയിലെ മണലിന്റെ വില കാണാൻ എന്താണ് ചെയ്യേണ്ടത്?

(b) പ്രശ്നത്തിന്റെ രേഖാ ചിത്രം വരയ്ക്കൂ?

(c) ആകെ മണലിന്റെ വ്യാപ്തം (Volume) എത്രയാണ്?

(d) എങ്കിൽ മണലിന് ആകെ എത്ര രൂപയാകും?

6. 15 സമചതുര ബ്രിക്സുകൾ മേൽക്കുമേൽ വെച്ച് ദീർഘചതുരാകൃതിയിൽ നിർമ്മിച്ച ഒരു മതിലിന്റെ പരപ്പളവ് (area) 375 സ്ക്വയർഫീറ്റ് ആണ്. എങ്കിൽ ഈ മതിലിനു ചുറ്റും പതിച്ചിരിക്കുന്ന മര റീപ്പറിന് എത്ര നീളമുണ്ടായിരിക്കും.

(a) മതിലിനു ചുറ്റുമുള്ള മരറീപ്പറിന്റെ നീളം ഏത് മാർഗത്തിലാണ് കണ്ടുപിടിക്കുക?

(b) തന്നിരിക്കുന്ന മതിലിനെ ചിത്ര രൂപത്തിൽ എങ്ങനെ സൂചിപ്പിക്കാം?

(c) പരപ്പളവിൽ നിന്നും സമചതുരത്തിന്റെ വശത്തിന്റെ നീളം എങ്ങനെ കണ്ടു പിടിക്കാം?

(d) എങ്കിൽ റീപ്പറിന്റെ ആകെ നീളം എത്ര?

7. വൃത്താകൃതിയിലുള്ള ഒരു നടപ്പാതയുടെ സ്റ്റാർട്ടിംഗ് പോയിന്റിൽ നിന്നും പാതയുടെ പാതിവഴിയിലുള്ള റസ്റ്റിംഗ് പോയിന്റിലേക്ക് പാതയ്ക്ക് കുറുകെയുള്ള ദൂരം 100 മീറ്റർ ആണ്. പ്രഭാത സവാരിക്കിറങ്ങിയ വിനു പാതയ്ക്കുചുറ്റും 10 തവണ നടന്നുവെങ്കിൽ വിനു ആകെ എത്ര ദൂരം സഞ്ചരിച്ചു?

(a) വിനു ആകെ സഞ്ചരിച്ച ദൂരം കണ്ടു പിടിക്കണമെങ്കിൽ പാതയുടെ ഏത് അളവാണ് കണ്ടുപിടിക്കേണ്ടത്?

(b) പ്രശ്നത്തെ ചിത്ര രൂപത്തിൽ എങ്ങനെ സൂചിപ്പിക്കാം?

(c) പാതയുടെ ചുറ്റളവ് (Perimeter) കണ്ടുപിടിക്കാൻ ഏതൊക്കെ വിവരങ്ങളാണ് ലഭ്യമായിട്ടുള്ളത്?

(d) എങ്കിൽ വിനു ഒരു പ്രാവശ്യം നടന്ന ദൂരവുംആകെ നടന്ന ദൂരവും എത്രയാണ്?

8. ചതുരാകൃതിയിലുള്ള ഒരു ഇരുമ്പ് കട്ടയുടെ നീളം 20 സെന്റിമീറ്ററും വീതി 10 സെന്റിമീറ്ററും ഉയരം 5 സെന്റിമീറ്ററുമാണ്. ഇത് ഉരുക്കി ഒരു സമചതുരക്കട്ട (cube) ഉണ്ടാക്കിയാൽ ഒരു വശത്തിന്റെ നീളം എത്രയായിരിക്കും.

(a) ഈ പ്രശ്നം പരിഹരിക്കുന്നതിന് ആദ്യം രൂപീകരിക്കേണ്ട ആശയമെന്താണ്?

(b) ലഭ്യമായ വിവരങ്ങൾ ഉപയോഗിച്ച് രേഖാചിത്രം വരയ്ക്കൂ?

(c) രണ്ട് ചതുരക്കട്ടകളുടെയും വ്യാപ്തങ്ങൾ (Volume) എങ്ങനെ ബന്ധപ്പെട്ടിരിക്കുന്നു?

(d) എങ്കിൽ ഇതേ വ്യാപ്തമുള്ള സമചതുരക്കട്ടയുടെ ഒരു വശത്തിന്റെ നീളമെന്തായിരിക്കും?

9. ഒരു കുളത്തിന് 25 മീറ്റർ നീളവും 10 മീറ്റർ വീതിയും 4 മീറ്റർ ആഴവുമുണ്ട്. ഇതിൽ പകുതി ഉയരത്തിൽ വെള്ളമുണ്ട്. ഒരു മഴ പെയ്തപ്പോൾ ജലനിരപ്പ് 1 മീറ്റർ കൂടി ഉയർന്നുവെങ്കിൽ ആകെ എത്ര ലിറ്റർ വെള്ളം കൂടും? (ഒരുഘന മീറ്ററിൽ 1000 ലിറ്റർ വെള്ളം കൊള്ളും)

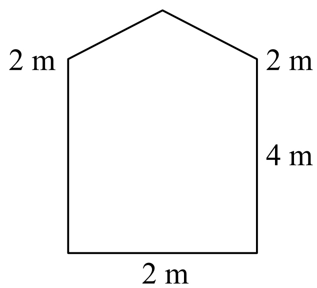
(a) ജലനിരപ്പിലെ വർദ്ധനവ് എങ്ങനെ കണക്കാക്കാം?

(b) ജലനിരപ്പിലെ വർധനവ് ലഭ്യമായ വിവരങ്ങൾ വെച്ച് വരച്ച് കാണിക്കൂ?

(c) മഴ പെയ്തതിനു ശേഷമുള്ള ജലത്തിന്റെ അളവ് എന്താണ്?

(d) എങ്കിൽ വെള്ളം എത്രയാണ് കൂടിയത്?

10. ഒരു കൊട്ടാരത്തിന്റെ ചുറ്റുമതിലിൽ ചിത്രത്തിലേതുപോലെ ഒരു വലിയ കവാടം നിർമ്മിക്കണമെങ്കിൽ എത്ര ചതുരശ്രമീറ്റർ ഭാഗം പൊളിച്ചു മാറ്റേണ്ടിവരും?



(a) കവാടം നിർമ്മിക്കണമെങ്കിൽ പൊളിച്ചുമാറ്റേണ്ട ഭാഗത്തിന്റെ എന്തളവാണ് കണ്ടെത്തേണ്ടത്?

(b) പൊളിച്ചുമാറ്റേണ്ട ഭാഗത്തിന്റെ കൃത്യമായ അളവ് ലഭിക്കുന്നതിന് കവാടത്തിന്റെ ആകൃതി എങ്ങനെ പരിഗണിക്കാം? വരയ്ക്കാമോ?

(c) ആകെ അളവ് ഏത് രൂപത്തിൽ കണ്ടെത്താം?

(d) എങ്കിൽ എത്ര ചതുരശ്രമീറ്റർ ചുറ്റുമതിലാണ് പൊളിച്ചു നീക്കേണ്ടി വരിക?

11. 10 മീറ്റർവീതിയുള്ളസമചതുരാകൃതിയിലുള്ള ഒരു പൂന്തോട്ടത്തിനുചുറ്റും 2 മീറ്റർ വീതിയിൽ പുൽപാത നിർമ്മിക്കുന്നു. ഇതിനായി എത്ര ചതുരശ്രമീറ്റർ പുല്ല്വാങ്ങേണ്ടി വരും?

(a) പുൽപാതയിൽ പതിക്കേണ്ട പുല്ലിന്റെ അളവ് അറിയണമെങ്കിൽ പാതയുടെ എന്തളവാണ് കണ്ടുപിടിക്കേണ്ടത്?

(b) പൂന്തോട്ടത്തെയും പാതയെയും എങ്ങനെ വരയ്ക്കാം?

(c) എങ്കിൽ പാതയുടെ വശങ്ങളുടെ അളവുകൾ എന്തായിരിക്കും?

(d) എങ്കിൽ പാതയുടെ പരപ്പളവ് (Area) എത്ര?

12. 16 സെന്റിമീറ്റർ നീളവും 8 സെന്റിമീറ്റർ വീതിയുമുള്ള ഒരു ചതുര കാർഡ്ബോർഡിൽ നിന്നും പരമാവധി വലിപ്പത്തിലുള്ള രണ്ട് വൃത്തങ്ങൾ വെട്ടിയെടുത്താൽ ബാക്കി വരുന്ന ഭാഗത്തിന്റെ പരപ്പളവ് എത്രയായിരിക്കും?

    (a) പരമാവധി വലിപ്പത്തിലുള്ള രണ്ട് വൃത്തങ്ങൾ വെട്ടിയെടുത്താൽ ബാക്കി വരുന്ന ഭാഗത്തിന്റെ പരപ്പളവ് (Area) കാണാനായി ചതുരത്തിന്റെ പരപ്പളവിനെയും രണ്ട് വൃത്തങ്ങളുടെ പരപ്പളവിനെയും എങ്ങനെ ബന്ധപ്പെടുത്താം?

    (b) പ്രശ്നത്തിന്റെ ചിത്രരൂപം വരച്ചു നോക്കൂ?

    (c) ചതുരത്തിന്റെയും വൃത്തത്തിന്റെയും പരപ്പളവ് എന്താണ്?

    (d) എങ്കിൽ ബാക്കിവരുന്ന ഭാഗത്തിന്റെ പരപ്പളവ് എങ്ങനെ കാണും?

13. ജാബിർ തന്റെ കൃഷിയിടം 4 മക്കൾക്കുമായി തുല്യമായിവീതിച്ചു നൽകി. ചതുരാകൃതിയിലുള്ള അയാളുടെ സ്ഥലത്തിന് 10 മീറ്റർ നീളവും 6 മീറ്റർ വീതിയുമാണുള്ളത്. എങ്കിൽ ഓരോരുത്തർക്കും എത്ര സ്ഥലം ലഭിച്ചിട്ടുണ്ടായിരിക്കും?

    (a) സ്ഥലത്തെ നാലായി വീതിക്കണമെങ്കിൽ ആദ്യം എന്താണ് ചെയ്യേണ്ടത്?

    (b) സ്ഥലത്തെ നാലുപേർക്കും വീതിച്ചു നൽകുന്നതിന്റെ രേഖാചിത്രം എങ്ങനെ വരയ്ക്കാം?

    (c) ഓരോരുത്തർക്കും തുല്യ അളവിൽ സ്ഥലം ലഭിക്കണമെങ്കിൽ ആകെ സ്ഥലത്തിന്റെ അളവിനെ എന്ത് ചെയ്യണം?

    (d) എങ്കിൽ ഓരോരുത്തർക്കും എത്ര ചതുരശ്രമീറ്റർ സ്ഥലം ലഭിച്ചിരിക്കും?

14. റോഡ് വികസനത്തിന് ഫിലിപ്പിന് 10 മീറ്റർ നീളത്തിലും 1 മീറ്റർ വീതിയിലും സ്ഥലം വിട്ടു നൽകേണ്ടി വന്നു. ഒരു സെന്റിന് ഒരു ലക്ഷം രൂപ നിരക്കിലാണ് സർക്കാർ നഷ്ടപരിഹാരം നൽകുന്നത്. എങ്കിൽ ഫിലിപ്പിന് ആകെ എത്ര രൂപ ലഭിക്കും? (1 m^2=0.02471 സെന്റ്)

    (a) ഫിലിപ്പിന് ആകെ എത്ര ചതുരശ്രമീറ്റർ സ്ഥലമുണ്ട്?

    (b) ഫിലിപ്പിന്റെ സ്ഥലത്തിന്റെ രേഖാചിത്രം വരച്ചു നോക്കൂ?

    (c) എങ്കിൽ ഫിലിപ്പിന് ആകെ എത്ര സെന്റ് സ്ഥലമുണ്ടാകും?

    (d) അപ്പോൾ ഫിലിപ്പിന് എത്ര രൂപ നഷ്ടപരിഹാരം ലഭിക്കും?

15. 6 മീറ്റർ വീതിയുള്ള ഒരു റോഡിനു കുറുകെ അർധ വൃത്താകൃതിയിൽ ഒരു ബലൂൺ കമാനം നിർമ്മിക്കണം. എങ്കിൽ ബലൂൺ ഫിക്സ് ചെയ്യാൻ എത്ര നീളത്തിലുള്ള കമ്പി വാങ്ങണം?

    (a) കമാനത്തിനാവശ്യമായ കമ്പി വാങ്ങണമെങ്കിൽ ഏതളവാണ് കണ്ടുപിടിക്കേണ്ടത്?

    (b) കമാനത്തിന്റെ രേഖാചിത്രം എങ്ങനെ വരയ്ക്കാം?

    (c) തന്നിരിക്കുന്ന അളവിൽ നിന്നും കമ്പിയുടെ നീളം കണ്ടുപിടിക്കാൻ എന്ത് ക്രിയ ചെയ്യണം?

    (d) എങ്കിൽ വാങ്ങേണ്ട കമ്പിയുടെ നീളമെത്ര?

Appendix II

FAROOK TRAINING COLLEGE

Affiliated to University of Calicut

PROBLEM SOLVING ABILITY TEST IN GEOMETRY (2019)

(ENGLISH - FINAL)

Std: IX Time : 1 ½ Hour

Rishad Kolothumthodi
Research Scholar

Dr. Manoj Praveen. G
Associate Professor

Instructions

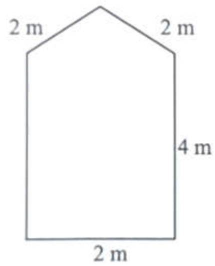
Following are few questions on geometry, picked up from life situations. For each questions, 4 sub questions are also provided to arrive at the solutions. Response for the questions should be based on your own logic and reasoning. For all the answers, essential diagrams as well as step by step process should be described.

1. Sarin walks 50 m straight from where he stands. Then he turns right and walks 30 m and turns right again and walks 50 m. How much more should he walk to reach at the place from where he began the journey?
   a) From the given context, what details do we have, to find the distance to be walked further to reach back to the place from where he began the journey?
   b) How can you draw the travelled path?
   c) By observing the drawn figure, how can you find the distance for completing the walk?
   d) Then, how much distance should Sarin walk more?
2. Two places are marked in a map at a distance of 5c.m apart. If 1 c.m is scaled by 10 km in the map, what is the actual distance between both these places?
   a) From the distance between the places given in the map, what method can be used to find the actual distance between the places?
   b) How can you represent the given information as a diagram?
   c) How is the distance in the map and actual distance between the places related?
   d) Find the actual distance between the places?
3. A bangle of diameter 4 cm was made by bending a gold rod. What would be the diameter of the bangle made from a gold rod of half this length?
   a) What is to be found?
   b) How do you draw a rough diagram using the given information
   c) What would be the length of the new gold rod, if half the length of the initial rod is taken?
   d) Find the diameter of the small bangle?

4. How many tiles are required for the floor of a room having 10 m length and 6 m breadth, if a tile's measurement are 1 m length and 50 c.m breadth?
   a) If the room's floor is to be tiled, what measurement of the room is required?
   b) How will you represent the given information pictorially
   c) To find the total number of tiles required, is it necessary to find the area of a single tile? If yes, how to find it?
   d) If so, how many tiles are required?
5. A lorry is filled with sand in dimensions of 4 m length, 2 m breadth and 1 m height. If 1 cubic meter of sand costs - 1000, what is the cost of the sand in the lorry?
   a) What is to be done to find the cost of the sand in the lorry?
   b) Draw a rough diagram of the given information
   c) What is the volume of the total sand?
   d) Find the cost of the sand?
6. The area of a rectangular fence wall made by placing 15 square bricks one over the other is 375 sq.ft. What would be the length of the wooden reaper laid on this wall?
   a) What method can be used to find the length of the wooden reaper laid on the wall?
   b) Represent the given fence measurements pictorially
   c) How to find the length of the side of the square using the area of the fence wall?
   d) What is the total length of the reaper?
7. There is a circular shaped garden with foot path along its boundary. From the footpath's starting point to half its distance, there is another path of length 100 m, cutting across the garden. During the morning walk, if Vinu walked 10 times along the footpath, how much distance did he cover in total?
   a) To find the total distance walked by Vinu, what measurement of the footpath is to be determined?
   b) Represent the given information graphically.
   c) To find the perimeter of the footpath, what details are given?
   d) Then, what is the distance covered by Vinu in one time as well as the total distance covered by him?
8. The length, breadth and height of a rectangular shaped iron block is 20 c.m, 10 c.m, 5 c.m respectively. If a new cube is formed by melting this, what would be the length of side of the cube?
   a) To solve this problem, what concept is to be formed initially?
   b) Using the given information draw a rough figure

c) What relation exists between the volumes of the two blocks ?
d) Then, what would be the side length of the new cube of the same volume?

9. If a gateway of the shape as shown in the figure is to be built on the fencing wall of a palace, how much area in Sq. m should be removed from the existing wall?



a) To build the gateway, what measurement of the part to be removed is to be found?
b) To get the correct measurement of the part to be removed, how can we relate the shape of the gateway with that? Draw it.
c) How can you determine the total measurement of this shape?
d) What sq. m area of the wall should be removed?

10. A pond of 25 m length, 10 m breadth and 4 m depth has water in half its height. After a rain, if the water level increased by 1 m, how much litres of water would increase?(1 cubic meter holds 1000 L of water)

a) How to determine the increase in water level?
b) Represent the increase in water level diagrammatically, using the given information,
c) What is the amount of water in the pond, after the rainfall?
d) Then, how much litres of water has increased?

11. A grass pavement of 2 m breadth is to be laid around a square shaped garden of width 10 m,. What sq. m of grass would be required for this?

a) To find the measurement of grass required, what measurement of the pavement is to be determined?
b) Represent the garden and pavement in a diagram
c) What would be measurement of the sides of the pavement?
d) What is the area of the pavement?

12. If two circles of maximum size are cut from a rectangular cardboard of length 16 m and breadth 8 m, what would be the area of the remaining part?

a) So as to find the remaining part's area, how can you relate the area of the two circles of maximum size and that of the rectangular cardboard?
b) Diagrammatically represent the given situation
c) What is the area of the rectangle and a circles?
d) How to determine the area of the remaining part?

13. Jabir partitioned his land equally for his 4 children. The length and breadth of his rectangular shaped land is 10 m and 6 m respectively. How much land would each one get?
    a) What is to be done first, to divide the land into 4 equal parts ?
    b) Diagrammatically represent this partition
    c) If each one should get land same area, what has to be done with the measurement of the total land?
    d) What sq.m of land would each one get?

14. For road development, Philip had to give away land in 10 m length and 1 m breadth. 1 lakh is the compensation for 1 cent of land. How much money would Philip get?
    a) What is the total sq. m of the land to be given away?
    b) Represent this information diagrammatically.
    c) How will you relate the area of the land to be given away in sq, m with corresponding area in cents.
    d) Find the compensation to be received by Philip?

15. A balloon arch is to be fixed across a 6 m wide road. What would be the length of the pipe to make this arch?
    a) To find the length of the pipe, what measurement is to be determined?
    b) Represent this information diagrammatically
    c) What calculation should be done to find the length of the pipe from the given information?
    d) What is the length of the pipe to be bought?

Appendix III

FAROOK TRAINING COLLEGE

Affiliated to the University of Calicut

SAMPLE LESSON TRANSCRIPT USED FOR TEACHING GEOMETRY WITH CONVENTIONAL INSTRUCTIONAL STRATEGY

(Malayalam)

Rishad Kolothumthodi — Research Scholar

Dr. Manoj Praveen. G — Associate Professor

Preliminary Details

Name of Teacher	:	Rishad Kolothumthodi	Name of School	:	Al Anwar High School
Subject	:	Mathematics	Class	:	IX
Unit	:	Prisms	Duration	:	
Topic	:	Cylinder	Date	:	

Learning outcomes

1) ഒരു സിലിണ്ടറിന്റെ പരപ്പളവു കണക്കാക്കുന്ന രീതി തിരിച്ചറിയുന്നു.
2) ഒരു സിലിണ്ടറിന്റെ പരപ്പളവ് കണക്കാക്കുന്നു.

Content analysis

Terms

സിലിണ്ടർ, പരപ്പളവ്, ചതുരം, വൃത്തം

Facts

- ഒരു ദീർഘചതുരം മടക്കി സിലിണ്ടറിന്റെ വക്ര തലം നിർമിക്കാം

Concepts

- ഒരു സിലിണ്ടറിന്റെ വക്രതല പരപ്പളവ് പാദചുറ്റളവിന്റെയും
- ഉയരത്തിന്റെയും ഗുണനഫലമാണ്.

Principles

- ഒരു സിലിണ്ടറിന്റെ വക്രതല പരപ്പളവ് = $2\pi rh$
- സിലിണ്ടറിന്റെ ആകെ പരപ്പളവ് = $2\pi rh + 2\pi r^2$

Definition

പാദം വൃത്താകൃതിയിൽ ആയ സ്തംഭത്തെ സിലിണ്ടർ (വൃത്തസ്തംഭം) എന്ന് പറയുന്നു.

Values and attitudes

- ദൈനംദിന ജീവിതത്തിൽ സിലിണ്ടറുകളുടെ പരപ്പളവു കണക്കാക്കുന്നു.
- ഗ്രൂപ്പ് വർക്കിലൂടെ സഹകരണ മനോഭാവം വികസിപ്പിക്കുന്നു.
- ഗണിതത്തോടുള്ള താൽപര്യം വർദ്ധിക്കുന്നു.

Learning strategy

ചർച്ച, പ്രവർത്തങ്ങൾ

Learning Resources

PPT, ആക്റ്റിവിറ്റി കാർഡ്സ്, സിലിണ്ടറുകളുടെ മോഡലുകൾ, കത്രിക, സിലിണ്ടറിന് ചുറ്റും പൊതിയാൻ ചതുരകൃതിയിലുള്ള പേപ്പർ, സൂത്രവാക്യങ്ങൾ എഴുതിയ ചാർട്ട്.

Previous knowledge

ചതുരം, ചുറ്റളവ്, വൃത്തത്തിന്റെ പരപ്പളവ്

Expected products

സിലിണ്ടറിൽ നിന്ന് നിർമിച്ച ദീർഘചതുരം, പൂർത്തിയാക്കിയ ആക്റ്റിവിറ്റി കാർഡുകൾ.

Learning Activities	Responses / Assessment
<u>**ആമുഖ പ്രവർത്തനം**</u> വിദ്യാർത്ഥികളുമായുള്ള സൗഹൃദ സംഭാഷണത്തിലൂടെ അധ്യാപകൻ ക്ലാസ് ആരംഭിക്കുന്നു. സ്ക്രീനിൽ നിരവധി സിലിണ്ടർ വസ്തുക്കളെ കാണിക്കുകയും അവയിലെല്ലാം പൊതുവായ ആകൃതി യെക്കുറിച്ച് വിദ്യാർത്ഥികളോട് ചോദിക്കുകയും ചെയ്യുന്നു.ഒരു ഗ്യാസ് സിലിണ്ടർ കാണിക്കുകയും അതിന്റെ പേര് അതിന്റെ ആകൃതി ആയ സിലിണ്ടറിന്റെ പേരിൽ നിന്നാണ് വന്നതെന്ന് പറയുകയും ചെയ്യുന്നു. അധ്യാപകൻ ഒരു സിലിണ്ടർ പൊതിയാൻ ആവശ്യമായ പേപ്പറിന്റെ അളവും രൂപവും ചിന്തിക്കുന്ന ഒരു കുട്ടിയുടെ ചിത്രം കാണിക്കുന്നു. ദീർഘചതുരം, വൃത്തം എന്നിവയുടെ പരപ്പളവിനെക്കുറിച്ച വിദ്യാർത്ഥി കളോട് ചോദിക്കുന്നു. PPT ഉപയോഗിച്ച് വക്രതല പരപ്പളവ്, ഉപരിതല പരപ്പളവ് എന്നീ പദങ്ങൾ പരിചയപെടുത്തിയ ശേഷം സിലിണ്ടറിന്റെ വക്രതലം മാത്രം പൊതിയാനാണെങ്കിൽ എന്താണ് കണക്കാക്കേണ്ട തെന്ന് ചോദിക്കുന്നു, കൂടാതെ സിലിണ്ടർ മുഴുവനായി പൊതിയുക യാണെങ്കിൽ എന്ത് അളവാണ് കണ്ടെത്തേണ്ടിവരുക എന്നും ചോദി ക്കുന്നു.	

വികസന പ്രവർത്തനം ***പ്രവർത്തനം 1:*** അധ്യാപകൻ വിദ്യാർത്ഥികളെ ഗ്രൂപ്പുകളായി തിരിക്കുകയും ആക്ടിവിറ്റി കാർഡുകളും ഒരു സിലിണ്ടറും ഒരു ജോടി കത്രികയും നൽകുന്നു. നിങ്ങളുടെ കൈയിലുള്ള സിലിണ്ടർ ലൈനിലൂടെ മുറിച്ച് ഇനിപ്പറയുന്ന ചോദ്യങ്ങൾക്ക് ഉത്തരം നൽകുക i) നിങ്ങൾക്ക് ലഭിക്കുന്ന ആകൃതി ii) ആകൃതിയുടെ പരപ്പളവ് കണക്കാക്കുന്നതിനുള്ള സൂത്രവാക്യം iii) പാദത്തിന്റെ പരപ്പളവ് കണക്കാക്കുന്നതിനുള്ള സൂത്രവാക്യം iv) സിലിണ്ടറിന്റെ വക്രതല പരപ്പളവ് കണക്കാക്കുന്നതിനുള്ള സൂത്രവാക്യം v) സിലിണ്ടറിന്റെ ആകെ ഉപരിതല വിസ്തീർണ്ണം കണക്കാക്കുന്നതിനുള്ള സൂത്രവാക്യം ചർച്ചാ സൂചനകൾ: • സിലിണ്ടറിന്റെ വക്രതല പരപ്പളവ് സിലിണ്ടറിനെ മുറിച്ചപ്പോൾ നിങ്ങൾക്ക് കിട്ടിയ പരപ്പളവ് ആണ്. • സിലിണ്ടറിന്റെ ഉപരിതല പരപ്പളവിന്റെയും വക്രതല പരപ്പളവിന്റെയും പാദപരപ്പളവിന്റെയും ആകെത്തുകയാണ്. 3, 4 എന്നിവയുടെ ഉത്തരം കണ്ടെത്താനായി നിങ്ങൾക്ക് ലഭിക്കുന്ന ആകൃതിയുടെ ഓരോ അളവുകളും താരതമ്യം ചെയ്ത് അതിനെ സിലിണ്ടറിന്റെ ഉയരം/പാദപരപ്പളവ്/പാദചുറ്റളവ് എന്നിവയിലേക്ക് മാറ്റുക. വിദ്യാർത്ഥികൾ ഉത്തരം കണ്ടെത്തുന്നു. കണ്ടെത്തിയ കാര്യങ്ങൾ ക്ലാസ്സിൽ അവതരിപ്പിക്കാൻ അധ്യാപകൻ വിദ്യാർത്ഥികളോട് ആവശ്യപ്പെടുന്നു. തുടർന്ന് അധ്യാപകൻ ഒരു സിലിണ്ടറിന്റെ മാതൃകയും ചതുരാകൃതിയിലുള്ള പേപ്പറും ഉപയോഗിച്ച് വിശദീകരിക്കുന്നു. സൂത്രവാക്യങ്ങളടങ്ങിയ ചാർട്ട് കാണിക്കുന്നു. ***സിലിണ്ടർ*** വക്രതലപരപ്പളവ് = $2\pi rh$ ഉപരിതലപരപ്പളവ് = $2\pi rh + 2\pi r^2$ ക്രോഡീകരണം i) ചതുരം ii) നീളം × വീതി iii) πr^2 iv) $2\pi rh$ v) $\pi r^2 + 2\pi rh$	

പ്രവർത്തനം -2

അധ്യാപകൻ ppt-ൽ ഒരു ചോദ്യവും അത് പരിഹരിക്കാനുള്ള സൂചനകളും അവതരിപ്പിക്കുന്നു.

ചോദ്യം : ഒരു റോഡ് റോളറിന്റെ ആരം 0.4 മീറ്ററും അതിന്റെ നീളം 1.2 മീറ്ററുമാണ്. ഒരു തവണ ഉരുളുമ്പോൾ നിരത്തിയ പ്രതലത്തിന്റെ പരപ്പളവ് എത്ര?

വിദ്യാർത്ഥികൾ അത് പരിഹരിക്കുകയും അധ്യാപകൻ ഒരു വിദ്യാർത്ഥി യോട് ഉത്തരം ബോർഡിൽ എഴുതാൻ ആവശ്യപ്പെടുകയും ചെയ്യുന്നു.

ക്രോഡീകരണം

$r = 0.4m$

$h = 1.2m$

വക്രതല പരപ്പളവ് $= 2\pi rh$

$= 2 \times \pi \times 0.4 \times 1.2$

$= 0.96\ m^2$

സമാപന പ്രവർത്തനം

വക്രതല പരപ്പളവിനെക്കുറിച്ചും ഉപരിതല പരപ്പളവിനെ ക്കുറിച്ചും അധ്യാപകൻ വിദ്യാർത്ഥികളോട് ചോദിക്കുന്നു. അദ്ദേഹം ചില ചോദ്യങ്ങൾ ബോർഡിൽ അവതരിപ്പിക്കുകയും ചുവടെയുള്ള ഓരോ ചോദ്യങ്ങൾക്കും വക്രതല പരപ്പളവാണോ ഉപരിതല പരപ്പളാ വാണോ കണ്ടെത്തേണ്ടതെന്ന് തിരിച്ചറിയാൻ വിദ്യാർത്ഥികളോട് ആവശ്യപ്പെടുകയും ചെയ്യുന്നു.

1) നന്ദുവിന് തന്റെ പുതിയ സിലിണ്ടർ അകൃതിയിൽ ഉള്ള പാത്രം പെയി ന്റ് ചെയ്യണം. ഒരു m^2 പെയിന്റ്റെ ചയ്യാൻ എത്ര പെയിന്റ് വേണ്ടിവരും?
2. ജേക്കബിന് ഒരു പ്രൊജക്റ്റിനായി ഒരു ഒഴിഞ്ഞ ക്യാൻ ലേബൽ കള ഞ്ഞു ഉപയോഗിക്കണം. ആ ലേബലിന്റെ പരപ്പളവ് എത്ര ആയിരിക്കും?
3) പരീക്ഷണാവശ്യങ്ങൾക്കായി ഒരു സിലിണ്ടർ അകൃതിയിൽ ഉള്ള മുറി നിർമ്മിച്ചു. നിർമ്മാണത്തിന് ആവശ്യമായ മെറ്റലിന്റെ അളവ് എത്രയാണ്?
4. ടീനയുടെ വിവാഹത്തിന് ഒരു സിലിണ്ടർ അകൃതിയിൽ ഉള്ള കേക്ക് ഓർഡർ ചെയ്തു. ഇത് അലങ്കരിക്കാൻ എത്ര ക്രീം വേണ്ടിവരും?
5. 20cm ഉയരവും 0.5cm വ്യാസവുമുള്ള ഒരു പേപ്പർ സ്ട്രോ നിർമ്മിക്കാൻ ആവശ്യമായ പേപ്പറിന്റെ പരപ്പളവ് എന്താണ്?

തുടർപ്രവർത്തനം

ഒരു കിണറിന്റെ ആന്തരിക വ്യാസം 2.5 മീറ്ററും ആഴം 8 മീറ്ററുംആണ്. $350/m^2$ എന്ന നിരക്കിൽ അതിന്റെ ഉള്ളിൽ സിമന്റ് ചെയ്യുന്നതിനുള്ള ചെലവ് എത്രയായിരിക്കും?

Appendix IV

FAROOK TRAINING COLLEGE

Affiliated to University of Calicut

SAMPLE LESSON TRANSCRIPT USED FOR TEACHING GEOMETRY WITH CONVENTIONAL INSTRUCTIONAL STRATEGY

(ENGLISH)

Rishad Kolothumthodi
Research Scholar

Dr. Manoj Praveen. G
Associate Professor

Preliminary Details

Name of Teacher	:	Rishad Kolothumthodi	Name of School	:	Al Anwar High School
Subject	:	Mathematics	Class	:	IX
Unit	:	Prisms	Duration	:	40 minutes
Topic	:	Cylinder	Date	:	

Learning Outcomes

- Identifies the method to calculate area of a cylinder
- Calculates area of a cylinder

Content Analysis

Terms:

Cylinder, area, rectangle, circle

Facts:

The curved part of a cylinder can be formed by folding a rectangle.

Concepts:

The curved surface area of a cylinder is the product of the base perimeter and height

Principles:

Curved surface area of a cylinder = $2\Pi rh$

Total surface area of a cylinder = $2\Pi rh + 2\Pi r^2$

Definition:

A cylinder is a prism with a circle as its base.

Values and Attitudes:

Calculates areas of cylinders in real life, develops cooperative skills by group work, increasing interest towards mathematics.

Learning strategy:

Discussion, Activity

Learning Resources:

Power point presentation, activity cards, models of cylinders, scissors, rectangular sheet to wrap around cylinder, chart with formulas.

Previous Knowledge:

Area of rectangle, perimeter and area of circle

Expected products:

Rectangle from cylinder, completed activity cards, notebooks with solved problems

Learning Experiences	Responses
INTRODUCTORY ACTIVITY Teacher begins the class through casual talk with students. He displays many cylindrical objects on screen and asks them about common shape in all of them. He shows a gas cylinder and says its name came from the name of the shape – CYLINDER. He shows an image of a boy who was thinking of the amount and shape of paper required to pack a real cylinder. He asks them about the area of shapes like rectangle and circle. He introduced the terms curved surface area and total surface area using slides and asks them what has to be calculated if he wrap the curved area only and if he wrap the curved areas and bases also. **DEVELOPMENTAL ACTIVITY** **Activity 1** Teacher divides the students into groups and distributes activity cards and a cylinder and a pair of scissors. Cut the cylinder in your hand through the line and answer the following questions i) The shape that you get is _____________. ii) Formula to calculate the area of the shape is _________.	

Learning Experiences	Responses
iii) Formula to calculate the area of the base circle is _____. iv) Formula to calculate curved surface area of cylinder is ___ v) Formula to calculate total surface area of cylinder is _____ ***Discussion Hints :*** • Curved surface area of the cylinder is the area you get by cutting the cylinder. • Total surface area is the sum of curved surface area and areas of base circles. • Towards the solution of 3 and 4 , compare each attributes of the shape you get and replace it with height/ base area/ base perimeter of the cylinder.	
Students solve the problem and teacher asks students randomly to give the answer. He uses a model of cylinder and a rectangular sheet to explain this. He hangs a chart of the formulas on the wall. **Cylinder** **Curved surface area = 2Πrh** **Total surface area = 2Πrh + 2Πr^2** **Consolidation** i) Rectangle ii) Length * breadth iii) Πr^2 iv) 2Πrh v) 2Πrh +2Πr^2 **Activity -2** Teacher presents a question on ppt and the hints to solve it. Q. The radius of a road roller is 0.4m and it is 1.2m long. What is the area of the levelled surface when it rolls once? Students solve it and teacher asks a random student to present it on board. Consolidation: r = 0.4m h = 1.2m Curved surface area = 2Πrh = 2Π*04*1.2	

Learning Experiences	Responses
$= 0.96\Pi m^2$	
Concluding activity Teacher asks students randomly about curved surface area and total surface area. He presents some questions on board and asks students to identify what they to find for each questions below? Curved surface area or total surface area? 1. Nandu wants to paint his new cylindrical container. How much paint is required per m^2? 2. Jacob uses an empty can for a project. He peels the label off. Find the area of label. 3. A cylindrical room was constructed for experimental purpose. What is the amount of metal required for construction? 4. A cylindrical cake was ordered for Tina's wedding. What is the amount of cream required to decorate it? 5. What is the area of paper required to make a paper straw of height 20c.m and diameter 0.5c.m? **Follow up activity** The inner diameter of a well is 2.5m and is 8m deep. What would be the cost of cementing its inside at Rs 350/ m^2?	

Appendix V

FAROOK TRAINING COLLEGE

Affiliated to University of Calicut

SAMPLE LESSON TRANSCRIPT USED FOR TEACHING GEOMETRY WITH VIRTUAL LEARNING ENVIRONMENT USING GEOGEBRA – MODULE II

(English)

Rishad Kolothumthodi	**Dr. Manoj Praveen. G**
Research Scholar	Associate Professor

Preliminary Details

Name of Teacher	:	Rishad Kolothumthodi	Name of School	:	Al Anwar High School
Subject	:	Mathematics	Class	:	IX
Unit	:	Prisms	Duration	:	
Topic	:	Volume of a Polygon	Date	:	

Module 2 - Volume of a Polygon

Introduction

The second module is introduced with an animation to make the concept of volume clear.

Volume of a rectangular Prism

Then an animated video of constructing a rubrics cube with small cubes of specific length, breadth and height is presented.

Later a provision is provided for the leaners to construct a rectangular prism with smaller cubes of unit length, breadth and height using Geogebra.

An illustration of finding the number of cubes with unit size in a rectangular prism is given.

From the above experiences it has been consolidated that the volume of a rectangular prism will be equal to the product of its length, breadth and height.

A demonstration of three rectangular prisms with same dimensions kept on the floor with its various faces on top is given next, explaining the concept of volume to be same for a single rectangular prism even if it is placed in lengthwise, breadth wise or height wise.

An application level problem is then provided to assess the attainment of the concept. The problem is presented in such a way that the learner has to make use of the various cognitive skills in problem solving. Necessary diagrammatic support is also given,

At this level a Geogebra button is provided, to find the volume of a rectangular prism.

Volume of triangular prism

A thought regarding computing the volume of any prism using the concept attained to find the volume of a rectangular prism is instilled with the support of necessary images.

First a right triangular prism is considered. A Geogebra button is provided to convince them that, two right triangular prism makes a rectangular prism.

Then, the concept of volume of any triangular prism is the product of its base and height is demonstrated with necessary diagrams and the formula for the same has been derrived.

Construction of prism with triangular prism

A picture illustrating splitting of a polygon to many triangles by joining one vertex to all other vertices is then given. An animation created with Geogebra is then provided, showing a splitting of a prism into many triangular prisms and its reunion to make the concept more clear.

Consolidation

The concept that the volume of any prism is the product of its base area and height is further demonstrated with graphical support. It is followed by a Geogebra applet to construct a rectangular prism with triangular prisms.

Review

Two interactive application level problems are then provided to assess the attainment of the concept.

Appendix VI

FAROOK TRAINING COLLEGE

Affiliated to University of Calicut

VIRTUAL LEARNING ENVIRONMENT USING GEOGEBRA – SCRIPT FOR MODULE II (SAMPLE)

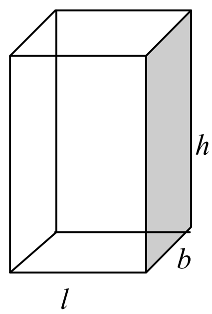
(Malayalam)

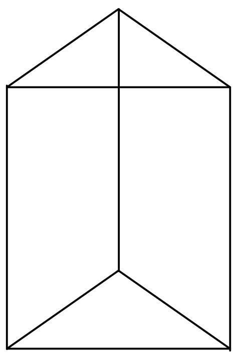
Rishad Kolothumthodi Research Scholar

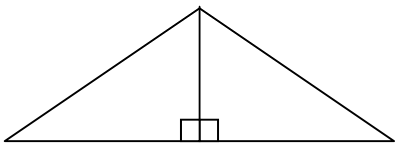
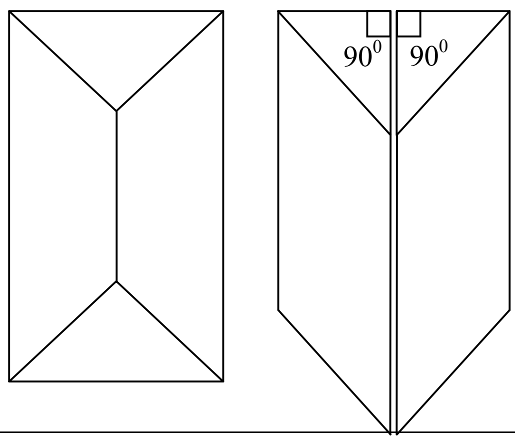
Dr. Manoj Praveen. G Associate Professor

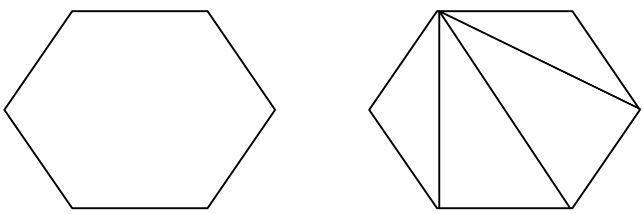
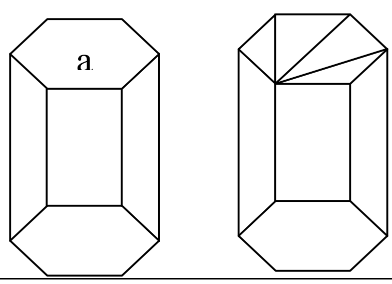
ബഹുഭുജ സ്തംഭത്തിന്റെ വ്യാപ്തം

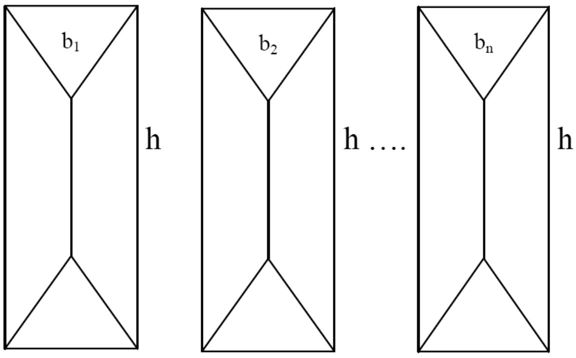
Content	Remarks/Effect
വ്യാപ്തത്തെ കുറിച്ച് ചെറിയ ക്ലാസിൽ നിന്നും ധാരണ ലഭിച്ചിട്ടുണ്ടല്ലോ. കൂടുതൽ വ്യക്തത നേടാനായി ഈ വീഡിയോ / ആനിമേഷൻ കണ്ടു നോക്കൂ... →	വൃത്തസ്തംഭാകൃതിയിലുള്ള ഒരു പാത്രത്തിലേക്ക് ജ്യൂസ് ഒഴിക്കുന്നതും ഒഴിക്കുന്നതിനനുസരിച്ച് പാത്രം നിറയുന്നതും കാണിക്കണം.
അതായത് നിശ്ചിത ആകൃതിയിലുള്ള ഒരു ത്രിമാന രൂപത്തിൽ ഉൾക്കൊള്ളുന്ന പദാർത്ഥത്തിന്റെ അളവാണ് വ്യാപ്തം കൊണ്ട് സൂചിപ്പിക്കുന്നത്.	
റൂബ്രിക്സ് ക്യൂബ് എങ്ങനെയാണ് നിർമ്മിക്കപ്പെട്ടിരിക്കുന്നത്?	
ഒരു റൂബ്രിക്സ് ക്യൂബിൽ നിശ്ചിത അളവിലുള്ള എത്ര ചെറിയ കട്ടകൾ ഉൾക്കൊണ്ടിരിക്കുന്നു. ആനിമേറ്റഡ് വീഡിയോ കണ്ടു നോക്കൂ.........	റൂബ്രിക്സ് ക്യൂബിന്റെ Animated Video
ഇങ്ങനെ ഏതൊരു ചതുരക്കട്ടയുടെതും കണ്ടുപിടിച്ചു കൂടെ?	
ജിയോജിബ്ര ഉപയോഗിച്ച് നിശ്ചിത അളവുകളുള്ള ചെറിയ ചതുരക്കട്ടകൾ ഉപയോഗിച്ച് ഒരു വലിയ ചതുരക്കട്ട ഉണ്ടാക്കി നോക്കിയാലോ ? →	GeoGebra
5cm നീളവും 3 cm വീതിയും 2cm ഉയരവുമുള്ള ഒരു വലിയ ചതുരക്കുഴിയിൽ നിന്നും 1 cm നീളവും വീതിയും ഉയരവുമുള്ള 30 ചെറിയ ചതുരക്കട്ടകളുണ്ടാക്കാം...	
അതായത് ആകെ ചെറിയ ചതുരക്കട്ടകളുടെ എണ്ണം $= 5 \times 3 \times 2 = 30$	

Content	Remarks/Effect
ഇവിടെ വലിയ ചതുരക്കട്ടയിൽ 1 cm നീളവും 1 cm വീതിയും 1cm ഉയരവുമുള്ള 30 ചെറിയ ചതുരക്കട്ടകൾ ഉൾക്കൊള്ളുന്നത് കൊണ്ട് വ്യാപ്തം 30 cm^3 ആണെന്ന് നാം മനസ്സിലാക്കിയല്ലോ... അതായത് ചതുരക്കട്ടയുടെ പാദമുഖത്തിന്റെ നീളത്തെയും വീതിയെയും ഉയരം കൊണ്ട് ഗുണിച്ചപ്പോഴാണല്ലോ വ്യാപ്തം കിട്ടിയത്. ചതുരത്തിന്റെ നീളവും വീതിയും ഗുണിച്ചാൽ പരപ്പളവ് ലഭിക്കുമെന്ന് നേരത്തെ പഠിച്ചതാണല്ലോ... അങ്ങനെയെങ്കിൽ ഏതൊരു ചതുരസ്തംഭത്തിന്റെയും വ്യാപ്തമെന്നത് പാദപരപ്പളവിന്റെയും ഉയരത്തിന്റെയും ഗുണനഫലമാണെന്ന നിഗമനത്തിൽ എളുപ്പത്തിൽ എത്തിച്ചേരാമല്ലോ... വ്യാപ്തം = നീളം × വീതി × ഉയരം = പാദപരപ്പളവ് × ഉയരം	
ഒരു ചതുരസ്തംഭത്തെ മൂന്ന് തരത്തിൽ വെച്ച ചിത്രങ്ങൾ വ്യത്യാസ്തമായി വരുന്ന രീതിയിൽ കാണണം. നീളം, വീതി, ഉയരം മാർക്ക് ചെയ്യണം. വ്യാപ്തം $= 3 \times 2 \times 5 = 30$ $= 5 \times 3 \times 2 = 30$ $= 5 \times 2 \times 3 = 30$	3 images at the centre with same dimension but placed in 3 different ways
ചിത്രത്തിൽ നിന്നും, ഏതൊരു ചതുരസ്തംഭത്തിന്റെയും എല്ലാ മുഖങ്ങളും ചതുരമായതിനാൽ ഏതു മുഖവും പാദമുഖമായും എടുക്കാമെന്നും വ്യക്തമായല്ലോ... (മറ്റു സ്തംഭങ്ങൾക്ക് പറ്റില്ല എന്ന Concept കൂടി വരണം. സമചതുര സ്തംഭത്തിന് പറ്റും.)	
അങ്ങനെയെങ്കിൽ ഒരു ലോറിയുടെ കണ്ടെയ്നറിന് 5 മീറ്റർ നീളവും 2.5 മീറ്റർ വീതിയും 3 മീറ്റർ ഉയരവുമുണ്ടെങ്കിൽ അതിൽ 3 മീറ്റർ ഉയരവും 1 മീറ്റർ നീളവുമുള്ള 0.5 മീറ്റർ വീതിയുമുള്ള എത്ര അലമാരികൾ കൊണ്ടുപോകാം.	Assessment problem Images of lorry and container with measurements

Content	Remarks/Effect
(മറ്റൊരളവിലാണെങ്കിലോ... ഇതുപോലെ അടുക്കിവെച്ചാൽ ശരിയാകുമോ...) ഇവിടെ എന്താണ് കണ്ടെത്തേണ്ടത്? ലഭ്യമായ വിവരങ്ങൾ എന്തൊക്കെയാണ്? തന്നിരിക്കു വിവരങ്ങളെ ബന്ധപ്പെടുത്തി നോക്കുക. ഉത്തരം കാണുന്നതിനായി നേരത്തെ പഠിച്ച രീതി എവിടെയാണ് പ്രയോഗിക്കേണ്ടത്? ഇനി ഉത്തരം കണ്ടെത്തിക്കൂടെ? ജിയോജിബ്രയിൽ വരച്ച ഒരു സ്തംഭത്തിന്റെ വ്യാപ്തം എളുപ്പത്തിൽ കാണുന്നത് എങ്ങനെയെന്ന് നോക്കിയാലോ...	GeoGebra.applet
<u>ത്രികോണ സ്തംഭത്തിന്റെ വ്യാപ്തം</u> പാദപരപ്പളവിനെ ഉയരംകൊണ്ടു ഗുണിച്ച് ചതുരസ്തംഭത്തിന്റെ വ്യാപ്തം കണ്ടെത്തിയതു പോലെ ഏതൊരു ബഹുഭുജ സ്തംഭത്തിന്റെയും വ്യാപ്തം കണ്ടുപിടിക്കാൻ സാധിക്കുമോ? പരീക്ഷിച്ചു നോക്കിയാലോ ....? ആദ്യം ഒരു മട്ടത്രികോണ സ്തംഭം പരിഗണിക്കാം  ഇതുപോലെയുള്ള രണ്ട് മട്ടത്രികോണസ്തംഭങ്ങൾ ചേർന്ന് ഒരു ചതുരസ്തംഭമുണ്ടാക്കാമല്ലോ... ജിയോജിബ്രയിൽ ചെയ്തുനോക്കൂ.......... അഗ്രമുഖം മട്ടത്രികോണാകൃതിയിലുള്ള സ്തംഭത്തിന്റെ പാദപരപ്പളവ് a എന്നെടുത്താൽ, രണ്ട് മട്ടത്രികോണ സ്തംഭങ്ങൾ ചേർന്നുണ്ടാകുന്ന ചതുരസ്തംഭത്തിന്റെ പാദപരപ്പ് 2a ആണല്ലോ..	GeoGebra.applet

Content	Remarks/Effect
ത്രികോണ സ്തംഭത്തിന്റെയും ചതുരസ്തംഭത്തിന്റെയും ഉയരം ഒന്നുതന്നെയാണല്ലോ... അതിനെ h എന്നെടുത്താൽ ചതുര സ്തംഭത്തിന്റെ വ്യാപ്തം എത്രയാണ്. പാദപരപ്പളവ് × ഉയരം ചെയ്തുനോക്കിയാൽ 2ah എന്ന് കിട്ടുമല്ലോ... 2 ah രണ്ട് ത്രികോണ സ്തംഭങ്ങൾ ചേർത്തുവെച്ചുണ്ടാക്കിയ ചതുരസ്തംഭത്തിന്റെ വ്യാപ്തമാണല്ലോ... അങ്ങനെയെങ്കിൽ ഒരു ത്രികോണ സ്തംഭത്തിന്റെ വ്യാപ്തമോ...? ah എന്ന് കിട്ടുമല്ലോ... അതായത് പാദപരപ്പിന്റെയും ഉയരത്തിന്റെയും ഗുണനഫലംതന്നെ. ഇനി പാദം മട്ടത്രികോണാകൃതിയല്ലാത്ത സ്തംഭങ്ങളാണെങ്കിലോ... ഏതൊരു ത്രികോണത്തിന്റെയും ഒരു ശീർഷത്തിലൂടെ ലംബംവരച്ച് രണ്ട് മട്ടത്രികോണങ്ങളുണ്ടാക്കാം  അങ്ങനെയെങ്കിൽ ഏതൊരു ത്രികോണ സ്തംഭത്തെയും ഇതുപോലെ ഭാഗിച്ച് രണ്ട് മട്ടത്രികോണ സ്തംഭങ്ങളാക്കി മാറ്റി നേരത്തെ കണ്ടപോലെ വ്യാപ്തം കാണാമല്ലോ...  	Image at centre (Geogebra-രണ്ട് മട്ടത്രികോണ സ്തംഭങ്ങൾ കൂടിചേർന്ന് ഒരു ചതുരസ്തംഭമാകുന്ന ആനിമേഷൻ)

Content	Remarks/Effect
ത്രികോണ സ്തംഭത്തിന്റെ പാദപരപ്പ് a, ഭാഗിച്ചു കിട്ടുന്ന സ്തംഭങ്ങളുടെ പാദപരപ്പ് b, c എന്നെടുത്താൽ a = b + c ആയിരിക്കുമല്ലോ... ഉയരം എല്ലാ സ്തംഭങ്ങളുടെതും ഒന്നായതിനാൽ, ഇതിനെ h കൊണ്ട് സൂചിപ്പിക്കാം... എങ്കിൽ മട്ടത്രികോണങ്ങളുടെ വ്യാപ്തങ്ങളുടെ തുക bh + ch = (b + c) h = ah എന്ന് കിട്ടുന്നുവല്ലോ... ഇതുതന്നെയല്ലെ ആദ്യത്തെ ത്രികോണസ്തംഭത്തിന്റെ വ്യാപ്തം. ഇതിൽ നിന്നും ഏതൊരു ത്രികോണ സ്തംഭത്തിന്റെയും വ്യാപ്തം പാദപരപ്പളവിന്റെയും ഉയരത്തിന്റെയും ഗുണനഫലമാണെന്ന്മനസ്സിലാക്കാമല്ലോ... ഇപ്പോൾ ഏതൊരു ചതുര സ്തംഭത്തിന്റെയും ത്രികോണ സ്തംഭത്തിന്റെയും വ്യാപ്തം അതിന്റെ പാദപരപ്പിന്റെയും ഉയരത്തിന്റെയും ഗുണനഫലമായിരിക്കുമെന്ന് തെളിയിച്ച സ്ഥിതിക്ക് മറ്റു ബഹുഭുജസ്തംഭങ്ങളിലും ഇത് ശരിയായിരിക്കുമോ എന്ന് പരിശോധിക്കാം... ഒരു ത്രികോണത്തെ രണ്ട് മട്ടത്രികോണമായി ഭാഗിച്ചതുപോലെ ഏതൊരു ബഹുഭുജത്തിന്റെയും ഒരു നിശ്ചിതമൂലയും മറ്റെല്ലാ മൂലകളും യോജിപ്പിച്ച് ത്രികോണമാക്കി മാറ്റാമല്ലോ...	
	കഷ്ണിച്ച ത്രികോണ സ്തംഭങ്ങൾ ചേർന്ന് ബഹുഭുജ സ്തംഭം ഉണ്ടാക്കുന്ന (GeoGebra.applet)
അതുകൊണ്ട് ഏതൊരു ബഹുഭുജ സ്തംഭത്തെയും ഇതു പോലെ ത്രികോണ സ്തംഭങ്ങളാക്കി മാറ്റിക്കൂടെ... 	Corresponding images at centre

Content	Remarks/Effect
ബഹുഭുജ സ്തംഭത്തിന്റെ പാദപരപ്പ് a ആണെും ഉയരം h ഉം ആണെന്നിരിക്കട്ടെ.. ഈ സ്തംഭത്തെ n ത്രികോണ സ്തംഭങ്ങളാക്കി മുറിക്കാമല്ലോ... ഓരോ ത്രികോണ സ്തംഭത്തിന്റെയും പരപ്പ് b_1, b_2, b_3, ... b_n എന്നെടുക്കുകയാണെങ്കിൽ, ഓരോന്നിന്റെയും വ്യാപ്തം b_1h, b_2h, b_3h, ... b_nh എന്നാകുമല്ലോ...  അങ്ങനെയെങ്കിൽ ബഹുഭുജ സ്തംഭത്തിന്റെ വ്യാപ്തം $b_1h + b_2h + b_3h + ... + b_nh = (b_1 + b_2 + b_3 + ... b_n)\, h$ $= ah$ എന്ന് കിട്ടുമല്ലോ... ഇത്രയും പരീക്ഷണങ്ങളിൽ നിന്നും നമുക്ക് താഴെ പറയുന്ന നിഗമനത്തിലെത്താം. ഏതൊരു ബഹുഭുജ സ്തംഭത്തിന്റെയും വ്യാപ്തം പാദപരപ്പിന്റെയും ഉയരത്തിന്റെയും ഗുണനഫലമാണ്.	Corresponding images at centre
ഇനി നമുക്ക് ഒരു പ്രശ്നം പരിഹരിച്ചാലോ..... ഒരു ടോബ്ളെറോൺ ചോക്കലേറ്റ് പായ്ക്കിന്റെ പാദവശത്തിന്റെ നീളം 4 c.m ഉം ഉയരം 10 c.m ഉം ആണെങ്കിൽ അതിന്റെ വ്യാപ്തം എത്രയായിരിക്കും...? ഇവിടെ നമുക്ക് കണ്ടുപിടിക്കേണ്ടതെന്താണ്? ഒരു ബഹുഭുജ സ്തംഭത്തിന്റെ വ്യാപ്തം കണ്ടുപിടിക്കണമെങ്കിൽ അതിന്റെ എന്താണ് ആദ്യം അറിയേണ്ടത്....	Assessment Question

<table>
<tr><th>Content</th><th>Remarks/Effect</th></tr>
<tr><td>
ടോബ്ളെറോൺ ചോക്കലേറ്റ് പായ്ക്കിന്റെ ആകൃതി യെന്താണ്?

സമഭുജ ത്രികോണത്തിന്റെ വ്യാപ്തം കാണാൻ എന്തൊക്കെ അളവുകളാണ് ആവശ്യമുള്ളത്..

എന്തൊക്കെ അളവുകളാണ് ലഭ്യമായിട്ടുള്ളത്...

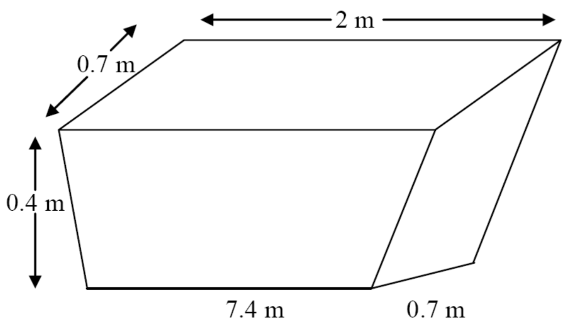
സമഭുജ ത്രികോണത്തിന്റെ പാദപരപ്പ് കാണാനുള്ള സൂത്രവാക്യം $\frac{3}{4}a^2$ ആണെന്ന് അറിയാമെങ്കിൽ പാദപരപ്പ് എത്രയായിരിക്കും?

പാദപരപ്പ് കിട്ടയാൽ വ്യാപ്തം കാണാനെളുപ്പമാണല്ലോ...

ചെയ്തു നോക്കൂ...
ഉത്തരം ശരിയാണോയെന്ന് പരിശോധിക്കൂ...

Pop up upon click ⇨

മറ്റൊരു പ്രായോഗിക പ്രശ്നം പരിഹരിച്ചാലോ...

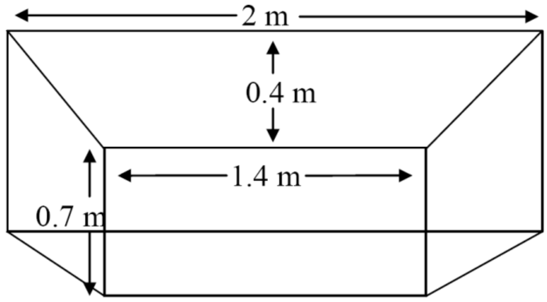


❖ ഈ ജലസംഭരണിയിൽ ഒരു ഘനമീറ്റർ സ്ഥല ത്ത് 1000 ലിറ്റർ വെള്ളം കൊള്ളുമെങ്കിൽ ആകെ എത്ര ലിറ്റർ വെള്ളം സംഭരിക്കാനാകും.

○ ഈ ജലസംഭരണിയെ ഒരു സ്തംഭമായി പരിഗണിക്കാനാകുമോ... മറിച്ചിട്ടു നോക്കിയാലോ...
</td><td>
പാദവശം, a = 4 cm
ഉയരം, h = 10 cm
സമഭുജ ത്രികോണത്തിന്റെ പാദപരപ്പ് $= \frac{\sqrt{3}}{4} a^2$
$= \frac{\sqrt{3}}{4} 16^2$
$= 4\sqrt{3}$
വ്യാപ്തം $= 4\sqrt{3} \times$ ഉയരം
$= 4\sqrt{3} \times 10$
$= 40\sqrt{3}\ cm^3$

Application Problem

ക്ലിക്ക് ചെയ്യുമ്പോൾ സമപാർശ്വലംബക സ്തംഭമായി മാറണം. ക്ലിക്ക് ചെയ്യുമ്പോൾ മറിഞ്ഞ് സമപാർശ്വലംബകസ്തംഭമാകണം. അളവുകൾ കൊടുത്തിരിക്കണം
</td></tr>
</table>

<table>
<tr><th>Content</th><th>Remarks/Effect</th></tr>
<tr><td>


○ ഇനി ഈ സംഭരണിയെ മുഖങ്ങൾ ഒരേ പോലെയുള്ള സമപാർശ്വ ലംബകങ്ങളായ സ്തംഭമായി പരിഗണിക്കാ മല്ലോ...
○ സംഭരണിയിൽ കൊള്ളുന്ന വെള്ളത്തിന്റെ അളവ് കാണണമെങ്കിൽ എന്താണ് കണ്ടുപിടിക്കേണ്ടത് ?
○ എന്തൊക്കെ വിവരങ്ങൾ നൽകിയിരിക്കുന്നു.
○ സമപാർശ്വ ലംബകത്തിന്റെ പരപ്പളവ് എങ്ങനെ കാണാം.
○ ഏതൊക്കെ അളവുകൾ വേണം.

സൂത്രവാക്യം $\frac{a+b}{2}$ h
അണെങ്കിൽ a, b, h എന്നിവ എത്രയാണ്.
ഇനി വ്യാപ്തം എളുപ്പത്തിൽ കാണാമല്ലോ...
ആകെ സംഭരണിയുടെ ശേഷി കാണണമെങ്കിലോ...
സഹായം ആവശ്യമാണോ...
</td><td>
GeoGebra

വ്യാപ്തം = പാദപരപ്പ് × h
സമപാർശ്വ ലംബകത്തിന്റെ പാദപരപ്പ് = $\frac{a+b}{2}$ h
a = 2m, b = 1.4m,
h = 0.4m
പാദപരപ്പ് = $\frac{1}{2}$ (2+1.4)×0.4
= 0.68 m^2
സംഭരണിയുടെ വ്യാപ്തം
= 0.68 × 0.7
= 0.476 m^3
ഒരു ഘനമീറ്ററിൽ 1000 ലിറ്റർ വെള്ളം കൊള്ളു മെങ്കിൽ സംഭരണി യിൽ ആകെ കൊള്ളുന്ന വെള്ളത്തിന്റെ അളവ്
= 0.476 × 1000
= 476ലിറ്റർ
</td></tr>
</table>

Appendix VII

MATRIX FOR EVALUATING PROBLEM SOLVING ABILITY TEST

Sl. No	Indicators	Scoring				
		Very suitable	Suitable	Acceptable	Need Improvement	Unsuitable
1	Statement of the problem					
2	Clarity in the language used					
3	Creating situation for problem solving					
4	Extend of Difficulty					
5	Extend of Simplicity					
6	Relevance with the topic					
7	Adequacy of information provided					
8	Applicability of problem solving skills					

Appendix VIII

RAVEN'S STANDARD PROGRESSIVE MATRICES

Sets A, B, C, D & E

RESPONSE SHEET

Name of Student :………………………….. Class :……………….......

Name of School :…………………………..... Male/ Female :…………………..

Test Started :………………………….. Test Ended :…………………..

A		B		C		D		E	
Sl.No	**Answer**	**Sl.No**	**Answer**	**Sl.No.**	**Answer**	**Sl.No**	**Answer**	**Sl.No**	**Answer**
1		1		1		1		1	
2		2		2		2		2	
3		3		3		3		3	
4		4		4		4		4	
5		5		5		5		5	
6		6		6		6		6	
7		7		7		7		7	
8		8		8		8		8	
9		9		9		9		9	
10		10		10		10		10	
11		11		11		11		11	
12		12		12		12		12	
Total		Total		Total		Total		Total	

Time	**Total Score**

Appendix IX

LIST OF SUBJECT AND TECHNOLOGY EXPERTS

1. Mr. PADMAPRASAD K.
   HST mathematics
   Pandallur higher secondary school, Malappuram
   State Resource person and teacher trainer, SCERT KERALA
   Resource Development Team member SCERT Kerala
   State level Geogebra trainer for teachers

2. C.P. ABDUL KAREEM
   HST Mathematics
   SOHSS Areekode
   SRG Member

3. Dr. M. SHAHEEDALI
   Senior Lecturer in Educational Technology
   DIET Palakkad

4. Mr. NASRULLAH T.P.
   Lecturer in Mathematics (PSTE)
   DIET Wayanad

5. Mr. ADEEB C.
   HST Mathematics
   JDT Islam HSS, Kozhikode

6. Dr. SAMEEHA RAHMANI
   Assistant Professor of Mathematics
   SS College, Areekode

7. Mr. UBAIDULLA K.C.
   SRG&DRG, Textbook Committee Member
   HST Mathematics
   SOHSS Areekod

8. Dr. ASHKARALI P.
   Assistant Professor
   C.H.M.K.M Govt. Arts & Science College, Tanur
   Department of electronics
   Specialist trainer of Learning Management Systems,
   Virtual learning environment and online course design.

9. Mr. SAMEERALI PILATHOTTATHIL
   HST Mathematics
   Govt. HSS, Thirurangadi

Appendix X

SOFT COPY (CD) OF THE VIRTUAL LEARNING ENVIRONMENT USING GEOGEBRA ON GEOMETRY