EFFECTIVENESS OF ICT
IN MATHEMATICS EDUCATION IN MIZORAM

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In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Mathematics of Mizoram University, Aizawl

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THESIS CERTIFICATE

This is to certify that the research thesis entitled ***Effectiveness of ICT in Mathematics Education in Mizoram*** submitted by ***L.Thangmawia*** to Mizoram University, Tanhril, Aizawl, for the award of the degree of Doctor of Philosophy is a bonafide record of research work carried out by him under our supervision. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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DECLARATION OF THE CANDIDATE

I, L.Thangmawia, hereby declare that the subject matter of my thesis entitled **"Effectiveness of ICT in Mathematics Education in Mizoram"** is the record of the work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A	Agree
ACF	Autocorrelation Function
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criteria
ARIMA	Autoregressive Integrated Moving Average
BC	Before Christ
BECTA	British Educational Communications and Technology Agency
CBSE	Central Board of Secondary Education
COVID-19	Coronavirus Disease
DA	Disagree
DEO	District Education Officer
DSE	Directorate of School Education
ET	Educational Technology
HSLC	High School Leaving Certificate Examination
HSS	Higher Secondary School
HSSLC	Higher Secondary School Leaving Certificate Examination
H/S	High School
ICME	International Congress on Mathematical Education
ICMI	International Commission on Mathematical Instruction
ICSE	Indian School Certificate Examinations
ICT	Information and Communication Technology
KMO	Kaiser-Meyer-Olkin
LCD	Liquid-crystal Display
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MBSE	Mizoram Board of School Education
MDT	Meta-Didactic Transposition
MIL	Modern Indian Language

MSA	Measurement Statistical Analysis
NCERT	National Council of Educational Research and Training
NCF	National Curriculum Framework
NCETM	National Centre for Excellence in the Teaching Mathematics
NCTM	National Council of Teachers of Mathematics
NEP	National Education Policy
NP	Negative Perception
NPE	National Policy on Education
OLS	Ordinary Least Square
P	Positive Perception
PACF	Partial-Autocorrelation Function
PTK	Pedogogic Technological Knowledge
RMSE	Root Mean Squared Error
SA	Strongly Agree
SCERT	State Council of Educational Research and Training
SD	Standard Deviation
SDA	Strongly Disagree
SDEO	Sub-Divisional Education Officer
TOI	Times of India
TPACK	Technological, Pedagogical and Content Knowledge
TV	Television
U	Undecided
UDISE	Unified District Information System for Education
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
VAI	Video Aided Instruction
VLTM	Video Teaching Learning Material

CHAPTER 1

INTRODUCTION

1.0 Introduction

There is no generally accepted definition of Mathematics. According to Oxford Dictionary, Mathematics is “the abstract science of number, quantity, and space, either as abstract concepts (*pure mathematics*), or as applied to other disciplines such as physics and engineering (*applied mathematics*)”. According to Merriam-Webster Dictionary, it is “the science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations”. It is well known that Mathematics is the study of quantity, structure, space and change. It uses abstraction and logical reasoning; from counting, calculation, measurement and the study of shapes and motion of physical objects. In the present scenario, it is generally accepted as an academic subject rather than its concept and definition.

Mathematics is the oldest science with the possible exception of astronomy. Nowadays it has been continuously pursued more than ever. Its origin situated veiled in the mists of antiquity and is regarded as the mother of all sciences in the modern world. It involves comprehension, reasoning, assessing, calculating, etc. with many different formulae, through which many questions and problems are solved. The world cannot move an inch without mathematics. Be it a cook or a farmer, a carpenter or a mechanic, a shopkeeper or a doctor, an engineer or a scientist, a musician, or a magician, everyone needs mathematics in their daily life. In mathematics alone, each generation made a new story to an old structure. It is the study of quantity, structure, space, counting, calculation, measurement and the study of the shapes and motions of physical objects. High standard in Mathematics without having a harmonious relationship with other subjects cannot be expected (TOI, 2015).

Without applying mathematics, it will not be possible to count members of the family, the number of students in the class, rupees in the pocket, days in a week or months or years, an engineer cannot build a bridge; and quantity checker chemist cannot prepare medicines, if he cannot accurately measure the quantity of each chemical. We couldn't have markets and businesses without mathematics as the world of trade runs on money. According to Roger Bacon, "Mathematics is the gateway and key of the sciences, neglect of mathematics works injury to all knowledge; since one who is ignorant of it cannot know the other things of the world, and what is worse, men who thus ignorant are unable to perceive their own ignorance and so do not seek a remedy".

It is important to start learning mathematics at a young age, to be able to count, add, subtract, multiply and divide is the first necessity in our mental development. The practice of teaching and learning of mathematics is necessary for mathematics education. It is a platform for imparting teaching and learning mathematics in a better way. Mathematics education is defined by a number of practices like the teaching and learning of mathematics at all levels in school and college, out of school learning of mathematics, the design, writing and construction of texts and learning materials. Mathematics education can be imparted through writing, calculating and speaking. It modifies the behavior of the individual and gives an understanding to the students.

Learning mathematics is essentially needed since it is a major instrument for future development in science and technology. The progress of a society depends largely on the development of mathematics education. Meanwhile, learning of mathematics is a common problem for the students at various levels in schools and can create phobic tendency in students. There are many causes for the students' phobic tendency in mathematics. Educationists have gone a long way in identifying phobic behavior of learners' until an objective of removing obstacles and enhancing better and meaningful learning, which will be required for adequate future development. The mathematics phobia is happened due to wrong style of teaching and learning of mathematics (Kunwar, 2020).

1.1 About Mizoram

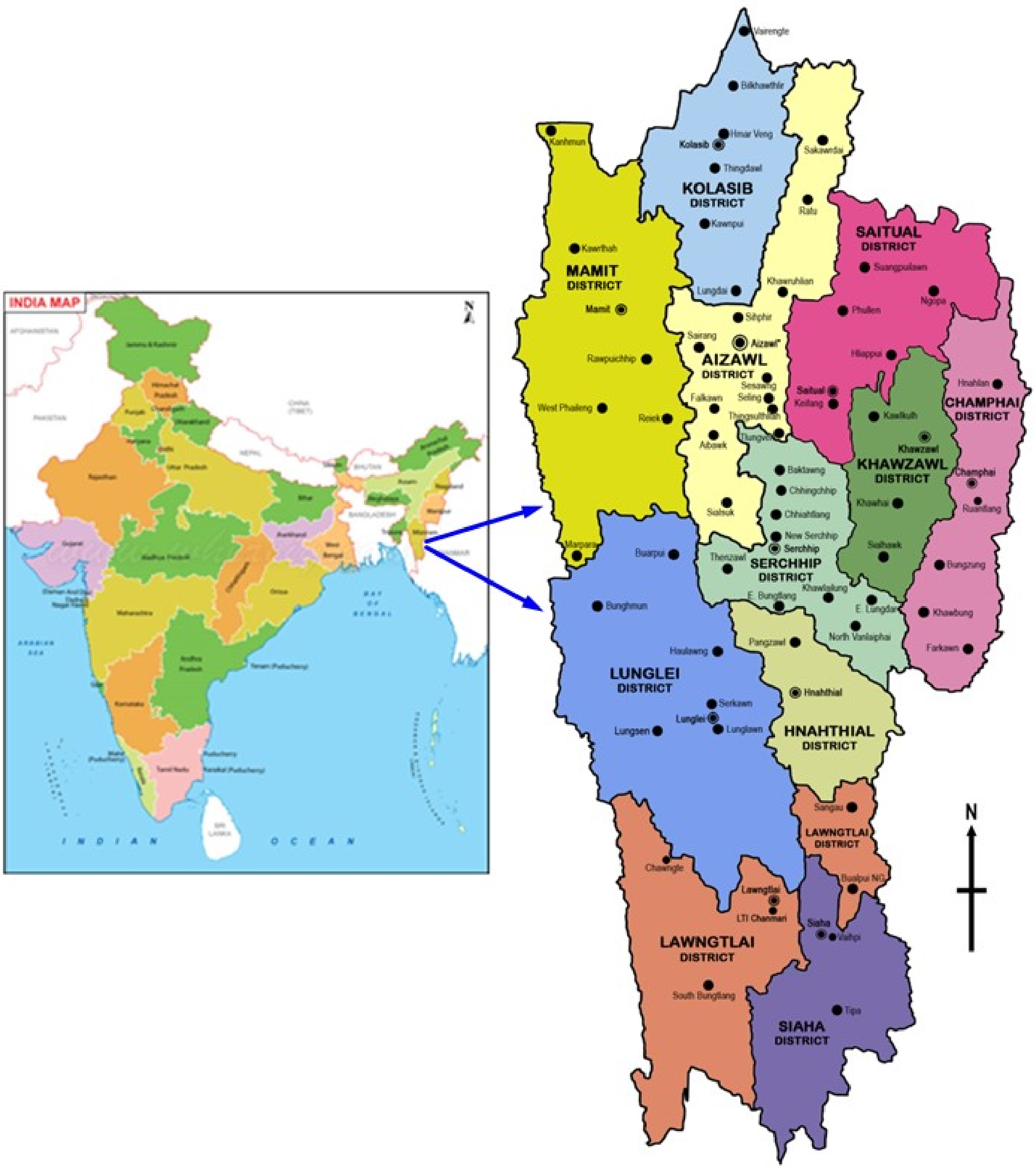


Figure 1.1: Map of Mizoram state

Mizoram is one of the states in India, sandwitched between Bangladesh in the west and Myanmar in the east. It covers an area of 12,087 Sq. kms. It is bounded in the north by the state of Assam and Manipur. Mizoram was an excluded area during the British colonial period. After Indian independence in 1947, it was one of the districts of Assam state till it attained Union Territory (UT) in 21st January, 1972. According to the 1971 census, the population of Mizoram was 3,32,390 with a literacy percentage of 53.79%. It attained statehood in 20th February, 1987. It shares 404 kilometres long international borders with Myanmar and 318 kilometres with Bangladesh. Geographical location of Mizoram is $92^0.15'$ E to $93^0.29'$ E Longitude and $21^0.58'$ N to $24^0.35'$ N Latitude. Aizawl is the capital city of Mizoram. There are 11 Districts, 23 Sub-Divisions and 26 RD Blocks. Its area covers 21,081 square kilometres. According to 2011 census, there are 830 villages, 2,22,853 households, 10,97,206 populations and literacy rate of 91.33% (Mizoram Statistical Handbook, 2020).

School Education in Mizoram is categorized broadly as elementary and secondary. Elementary Education covers classes 1 to 8 and Secondary Education covers classes 9 to 12. In Mizoram, the School Education Department looks after Government, Aided and Private Schools except Central Schools and the elementary schools within the three district councils of Lai Autonomous District Council, Mara Autonomous District Council and Chakma Autonomous District Council.

1.2 Mathematics Education in India

Mathematics has occupied an important position in the Indian education from time immemorial. The Indian sub-continent has long been recognized as extra ordinarily rich in mathematical heritage. Contribution of ancient India in Mathematics is remarkable. Concept of zero was also originated from India. Gandhiji propounded the idea of basic education in 1937 (Jena, 2020). Under the chairmanship of Dr. Zakir Hussain, a committee recommended that "Knowledge of Mathematics is an essential part of any curriculum" (Hussain, 1937).

Mathematics was made compulsory in school education by the Secondary Education Commission in 1952 (Report of the Secondary Education Commission 1952). The education commission 1964-66 recommended that Mathematics should be compulsory subject in school education (Report of the Education Commission 1964-66). The National Policy on Education (NPE) - 1986 suggested that "Mathematics should be visualized as a vehicle to train a child to think, reason, analyze and to articulate logically. Apart from being a specific subject, it should be treated as concomitant to any subject involving analysis and reasoning" (National Policy on Education, 1986).

The National Curriculum Framework (NCF-2005) highlighted that Mathematics education is mainly focused on student's resources to think and reason, to visualize abstractions and to solve problems. The infrastructure challenge is associated with the provision of computer hardware and software and connection to each school. The NCF- 2005 has given the vision for school mathematics education in India (National Curriculum Framework, 2005).

The National Education Policy (NEP), 2020 also gave importance to Mathematics Education. Para 4.25 of NEP, 2020 stated that "*It is recognized that mathematics and mathematical thinking will be very important for India's future and India's leadership role in the numerous upcoming fields and professions that will involve artificial intelligence, machine learning, and data science, etc. Thus, mathematics and computational thinking will be given increased emphasis throughout the school years, starting with the foundational stage, through a variety of innovative methods, including the regular use of puzzles and games that make mathematical thinking more enjoyable and engaging. Activities involving coding will be introduced in Middle Stage*" (National Education Policy, 2020).

1.3 Mathematics Education in Mizoram

Formal education in Mizoram started with the arrival of Christian Missionaries. The Christian Missionaries introduced the Roman scripts in 1894 with a phonetic form of spelling. The first government school was started in 1897 at Aizawl. They also began to open new schools in a few villages, such as Khawrihnim, Phulpui and Chhingchhip in 1901. In 1903, three more schools were opened and seven more in the next year. In 1909, the first ever Middle Schools were opened in Aizawl and Serkawn. In 1944, the first High School was started in Aizawl by public donations. The opening of High School marked a new epoch of event in the educational progress in the hilly area, now called Mizoram. For more than half a century, i.e. from 1895 to 1952, elementary education was looked after by Christian mission through Honorary Inspector of Schools. During the period between 1953 and

1972, the management of Primary Education was in the hand of District Council. When Mizoram became Union Territory in 1972, the administration and management of elementary education, i.e. Primary and Middle School was transferred to the government (Directorate of School Education website: retrieved on 16th June, 2022 *https://schooleducation.mizoram.gov.in/page/profile*).

Mathematics was included under Science umbrella in Mizoram (*Telephone Interview with former Director of Education, Dr. L.N. Tluanga on 15.9.2021, 11:36 AM*). Prior to 1973, Science was taught in Middle schools as General Knowledge dealing mainly with Biological Sciences. Science subject was made optional in High Schools and only few students took Science in High Schools and Colleges. Science Education in its true sense began only since 1973, when the UNICEF assisted Science Education programme was launched after the Government of the Union Territory of Mizoram signed a bond with the Government of India accepting the introduction of Science in 50 Primary and 30 Middle Schools. A new and separate wing for Science promotion (*Now called Science and Mathematics Promotion Wing under SCERT*) was created in the Education Department in 1973. A Science Promotion Officer and Science Consultants were appointed to look after and man the pilot project in Science and Mathematics Education. An Academic Officer for Science has also been appointed in the Mizoram Board of School Education, which was established in 1976 (MBSE Journal, 1982).

The then Chief Minister of Mizoram, Mr.Ch.Chhunga, in his speech at the inaugural function of MBSE on 26.4.1977 stated that "*While I am sure that the Board will take special measures to improve teaching of Science and Mathematics in our schools, I would like to make a special point about it, as I have no doubt that the developmental schemes of Mizoram will be badly impaired unless more and more of our school children get attracted to such studies*". (MBSE Journal, 1981).

In 1958, the first higher institution in Mizoram, Pachhunga University College was opened at Aizawl and the college introduced Science and Mathematics stream from the year 1973 (Zohmingliani, 2016). At present, apart from Pachhunga University College, other five colleges have Science and Mathematics stream as well

– Govt. Lunglei College introduced Science and Mathematics course in the year 1973, Govt. Kolasib College in 1987, Govt. Champhai College in 1997, Govt. Serchhip College in 1998 and Govt. Zirtiri Residential Science College in 2000.

Mizoram University was created by an Act of Parliament (No. 8 of 2000) and it became functional from 2nd July, 2001. Under Mizoram University, the Department of Mathematics and Computer Science came into existence in the year 2006 with the intake of first batch of Post Graduate students in July, 2007 and first batch of Ph.D. students in 2009.

Table 1.1: Growth of schools in Mizoram

Year	**Primary Schools**	**Middle Schools**	**High Schools**	**Higher Secondary Schools**	**Grand total**
1894	1	Nil	Nil	Nil	**1**
1903	3	Nil	Nil	Nil	**3**
1947	258	22	2	Nil	**282**
1972	425	184	70	Nil	**961**
1986	1017	443	154	Nil	**1614**
1996	1263	702	300	16	**2281**
1997	1318	733			**2396**
1998	1248				**1608**
1999	1226	748	383	18	**2344**
2000	1224	734	370	30	**2371**
2001	1377	851	409	33	**2631**
2002	1504	911		47	**2871**
2004	1481	939	448	67	**2935**
2005	1688	1121	474	125	**3408**
2006	1618	1081	492	80	**3271**

2007	1668	1090	496	82	**3336**
2008	1761	1117	342	59	**3279**
2009	1763	1180	362	70	**3375**
2010	1821	1353	538	98	**3810**
2011	1855	1383	543	113	**3894**
2012	1831	1381	584	118	**3914**
2013	1876	1408	612	127	**4023**
2014	1946	1514	610	132	**4202**
2015	1950	1511	614	138	**4213**
2016	1968	1542	640	163	**4313**
2017	1969	1580	669	175	**4393**
2018	1956	1553	691	186	**4386**
2019	1955	1550	707	197	**4409**

Source: Statistical Wing of Directorate of School Education; Government of Mizoram as on 16th June 2022

Table 1.2: Opening of Colleges/University offering Mathematics in Mizoram

Colleges	**Opening**	**Year of Introduction of Mathematics**
Pachhunga University College; Aizawl	1958	1973
Zirtiri Residential Science College; Aizawl	1980	2000
Gov't. Lunglei College; Lunglei	1963	1973
Gov't. Champhai College; Champhai	1971	1997
Gov't. Kolasib College; Kolasib	1977	1987
Gov't. Serchhip College; Serchhip	1973	1998
Mizoram University; Aizawl	2001	2006

Source: Field Work

1.4 ICT and Mathematics Education

ICT stands for Information and Communication Technology. ICT refers to any communication device or application such as radio, television, cellular phones, computer and network, hardware and software, and satellite systems. It also includes the services and applications related to the devices such as video conferencing and distance learning (Rajput, Raghuwanshi & Thakur, 2015). It helps to store, process, disseminate, retrieve and transmit information with the help of technology. ICT refers to technologies that provide information through telecommunications, internet, wireless networks, cell phones, and other communication mediums. ICT includes a range of hardware (e.g. desktop and portable computers, projection technology, calculators, data logging and digital recording equipment), software applications (e.g. generic software, multimedia resources) and information systems (Intranet). It also includes technologies using in the schools (e.g. interactive whiteboards) or those used across educational setting as well as both stand-alone and online, network technologies (Livingstone, 2012).

Students can use ICT for calculations, draw graphs for solving problems. Students of mathematics can use graphical calculators or graph plotters instead of algebra for solving an equation. They can smoothly perform a statistical analysis of the data for using the extensive statistical features of the graphical calculator. Creating an image in a dynamic geometry package can help a student understand, solve, and then prove a geometric problem. Students mostly use ICT as a tool to search things out, solve problems, or understand what's going on, which leads them to develop their skills in the use and application of mathematics. ICT can be an extensive and efficient tool if it is used constructively and efficiently (Das, 2019).

Generally, teaching is primarily focused on transaction of subject contents through lecture method, but with the application of technology, many technological tools are employed for the same. For example, Google meet, zoom, virtual experiments, power point presentation, video conferencing, internet, etc. are used during the teaching-learning process. Therefore, ICT is widely used in the field of teaching-learning processes. Likewise, in the field of assessment and evaluation, multiple tools and software are used. Online testing, computer tests, e-portfolios, etc. are used to assess learners' progress. That is why; ICT finds application in administration and management. ICT are also used in professional development programs (Amin, 2013).

The emergence of various learning resources has made the process of learning easy for learners. With the help of ICT learning resources, teachers can make learning more interesting and inculcate motivation among the students (Edwards et al., 1975). During the pre-digital era, teachers often used black boards, charts, models etc. for imparting knowledge in their classes. After the period of pre-digital era, teachers can use some of the digital learning resources like computer, e-books, educational software etc (Ayieko et al., 2017).

ICT offers various devices and learning sources that support the learning needs of learners with different types of students (Falck et al., 2018). It integrates education and prepares learners to develop adequate skills and all-round development (Drijvers, 2015). The efficiency and smartness of learning is advanced with the use of ICT. Learners learn better, comprehend knowledge with ease, retain longer period the learned contents and can easily apply them in practical situations. It helps in improvement of multiple skills both cognitive and physical development (TeachersAdda247, 2021).

Nowadays ICT plays an important role for integrating technology in the field of education (Idris, 2019). Technology can be the most effective way to improve the student's knowledge (Mervyn, 2006). With integration of ICT in education, the effectiveness of teaching and learning is enhanced. It added a new dimension of teaching and learning which was not previously available (Aunzo & Climaco, 2015).

With the help of ICT, the learners can upgrade their learning abilities. It gives huge online learning store room to office holders by means of computerized library and web. Use of sight and sound can give better learning to students. For monitoring the student activities in the class and generate feedback, application of video-conferencing is very effective. It can be utilized to upgrade instructive productivity at the nearby, territorial and national level (Chakraborty, Dhara & Santra, 2018).

Because of rapid development in ICT, especially in the field of internet, traditional initial teacher training and in-service continued training institutions worldwide are undergoing a rapid change in the structure and content of their training and delivery methods of their courses. However, combining new technologies with effective pedagogy has become a challenging task for both initial teacher training and in-service training institutions (Baya'a & Daher, 2012).

Researchers have proved that ICT can change the teaching method of teachers and this is especially useful in supporting more student-centered approaches to instruction and in developing the higher order skills and promoting collaborative activities (Churchhouse et al., 1986). Realizing the importance of ICT in teaching and learning, a majority of the countries in the world have provided ICT teacher training in multiple styles in forms and degrees (Dash, 2007; Delcourt & Kinzie, 1993)). Meanwhile many teachers reported that they have not had adequate training to prepare themselves for using technology effectively in their teaching and giving lecture to students (Clark-Wilson et al., 2014). Many teachers need to identify themselves for refreshing their style of teaching in a positive way (Kale, 2018).

The significance of ICT in learning can not be over emphasizing. ICT can improve the quality of instruction (Kulik & Kulik, 1991). Application of multimedia can transform the school by improving school management and can also enhance the tools and environment for learning. The use of ICT can also increase the quality of student learning (Yunusa, Lambisa and Yarima, 2019).

The benefit of ICT in teaching and learning is to give better value to students in their everyday life. Even teachers could also use ICT in order to facilitate learning, critical thinking and discussions. ICT can help learners by developing cognitive skills and critical thinking skills (Belay et al., 2020). It has the ability to improve efficiency in the educational process, memory retention, increase motivation as well as deepens understanding. It can be used to promote cooperative learning such as role playing, group problem solving activities and articulated projects. With the permission of using ICT in the work environment, rich network of interconnections and relation between individuals could be established. It can provide fast and accurate feedback to learners. ICT gives different needs of different learners and allow educators to respond in a better way (Alharbi, 2014).

According to Ittigson & Zewe (2003), technology is necessary for teaching and learning mathematics. ICT improves the way of teaching mathematics and improves students' understanding of basic concepts. Many researchers conducted studies to assess the benefits of using ICT in mathematics education.

Becta (2003) summarized the main advantages - ICT encourages more student cooperation and encourages the exchange of information and knowledge. ICT provides fast and accurate feedback to students, which contributes to positive motivation. It also allows them to focus on strategies and interpretations of answers rather than devoting time to annoying computations. ICT supports constructivist pedagogy, in which students use technology to study and understand mathematical concepts. This approach encourages more thoughtful thinking and better problem-solving strategies. The students would then use technology to focus on problem solving processes, rather than on problematic computing.

Integrating ICT in teaching requires a particular arrangement of abilities, encompassing innovation abilities, instructive practices, assessment methods, classroom management skills, applications and associations with content, and the ability to choose the correct device to finish the desired learning results (Ertmer and Ottenbreit-Leftwich, 2010; Keengwe and Anyanwu, 2007).

1.5 ICT initiative in Mizoram

The entire Mizoram state is mostly mountainous and due to these geographical factors, digital divide may be more pronounced in Mizoram. But at the same time, access to Information and Communication Technology (ICT) is a way to overcome issues of social and geographic isolation (Willis, 2006).

1.5.1 Establishment of ICT Department in Mizoram

The state government established the Department of Information and Communication Technology (ICT) in the year 2008 for planning, framing policy, monitoring and implementation of ICT and e-Governance projects.

Dr S.S. Garbyal, the Principal Secretary to the Govt. of Mizoram said, "The vision of the IT department in the state of Mizoram is to create a world class environment where major ICT companies can conduct their business and generate employment. Mizoram has one of the highest literacy rates in the country. The state has a huge potential in IT and ITES sector. But there are also the challenges. The most major challenge is the state's geographical distance from the major industrial hubs in the country. Recently we have signed MOU with Department of Electronics and IT, Government of India, and Mizoram University to setup Software Technology Park in the University Campus. I am confident that this will lead to a boost to the IT industry in the state in the fields of software development, software exports and ITES." (Elets News Network, 2012).

E-Governance Society of Mizoram has introduced ICT enabled education through an initiative "Creation of Education Technology Infrastructure in 50 Government Girl's Middle Schools of Mizoram". This project aims to popularize application of ICT in Classroom transactions for quality improvement of school education. The project was implemented in 50 Govt. Girl's middle schools of Mizoram. Teachers were also trained in the application of ICT in Education. The project also includes one year support service to each school selected for facilitating the project implementation and maintenance (ICT Department, Govt. of Mizoram, n.d.).

1.5.2 ICT initiatives under SCERT, Govt. of Mizoram

The State Council of Educational Research and Training (SCERT) established Educational Technology (ET) Cell in 1984. As per the guidelines laid down by the Central Government, the two schemes of Educational Technology (ET) and Computer Literacy & Studies in Schools (CLASS) Project were amalgamated into a composite schemes of Information & Communication Technology (ICT) in Schools Scheme w.e.f. 9.3.2004, vide Governments' Notification No.B.12019/34/ 2004-EDN dated 9.3.2004. The main activity of the ICT wing is the implementation of the ICT @ School Scheme in Mizoram. ICT @ School Scheme was introduced by the Ministry of Human Resource Development, Dept. of School Education and Literacy, Govt. of India with 90% funding from the State Government. Under the ICT @ School Scheme, 10 nos. of Computers and accessories have been provided to 276 nos. of Secondary and Higher Secondary School in the State.

EDUSAT started functioning since 2017 after the installation work at the HUB at SCERT and SITs were completed. The Mizoram EDUSAT Network has a total of 50 Satellite Interactive Terminals (SITs) located at various locations in Mizoram. These institutions include IASE, 8 DIETs, Higher Secondary Schools and High Schools across the state. EDUSAT functions under the guidance and direction of the ICT wing. All the technical equipments required at EDUSAT HUB are provided by the Indian Space Research Organisation (ISRO) in collaboration with Development of Educational and Communication Unit (DECU), Ahmedabad (SCERT, n.d.).

1.5.3 ICT @ Schools scheme under Samagra Shiksha Mizoram

Under Samagra Shiksha Mizoram, the mission of the ICT @ Schools scheme is to devise, catalyze, support and sustain ICT and ICT enabled activities and processes in order to improve access, quality and efficiency in the school system.

Out of 348 schools approved since financial year 2005-06 till financial year 2017-18 for implementation of ICT in schools, the State has covered all the 348 schools.

In addition to this, 4 smart schools are also covered as per approval of the MHRD. Again, after the erstwhile schemes of SSA, RMSA and TE have been integrated under the Samagra Shiksha scheme since financial year 2018-19, 23 Elementary schools and 9 Secondary Schools are also covered recently under ICT @

schools. The PAB 2020-21 has approved 40 Elementary Schools and 23 Secondary Schools (Samagra Shiksha Mizoram, n.d.)

1.6 Research in Mathematics Education

Research in Mathematics Education is to provide insightful learning between teachers and students. Research in mathematics education has primarily two purposes: first to better understand the nature of mathematical thinking, teaching, and learning; and second to use such knowledge in practice for learning and teaching mathematics. It is generally acknowledged that mathematics education has a social and political dimension (e.g. the importance of mathematics in society; the relevance of mathematics to other subjects; inclusion and exclusion in terms of gender, race and social class). Moreover, mathematics education as a research domain comprises also other educational sciences and disciplines such as sociology, psychology, anthropology, linguistics, philosophy, and more recently also neuroscience (EERA, n.d.)

According to Cai (2010), while mathematics has been a subject of study in school for many centuries, mathematics education is a relatively new field of study. Early in the twentieth century, it was established as an independent field of research. The most significant milestone was establishing The International Commission on Mathematical Instruction (ICMI) in 1908. In 1969, the first International Congress on Mathematical Education (ICME) was held in Lyon. Since then, the ICME is held every four years under the auspices of the ICMI. The aim of the Congress is to present the current states and trends in mathematics education research and the practice of mathematics teaching at all levels. In 2008, the 11th ICME was held in Monterrey, Mexico. In its first century, the field of mathematics education has prospered, particularly in the past four decades. The publications of research journals and training doctoral students are two indications for the prosperity of mathematics education as a field. Mathematics education, as a field of study, is multidisciplinary as well interdisciplinary and deals with theories, practices, policies, curriculum, and issues about the teaching and learning of mathematics. It is multidisciplinary, because the field adopts methods and perspectives in other disciplines, such as psychology and education, to study issues in mathematics education.

Bass (2005) argued that Mathematics education is not mathematics. It is a domain of professional work that makes fundamental use of highly specialized kinds of mathematical knowledge, and in that sense it can, and be usefully viewed as a kind of applied mathematics.

Ramanujam and Subramaniam (2012) stated that an important agenda for mathematics education in India is research in mathematics education. University departments, while undertaking research in education, by their typical structure, tend to attract largely people who are neither mathematically trained nor thus inclined.

Kapur (1997) had pointed out that "the main object of research in mathematics education is to be of help in improvement of classroom teaching and learning so that a large number of studies should be concerned with various aspects of this problem". He had suggested various dimensions of this research, including instruction based on the use of computer aided and other technology, study of effective teachers, styles of learning among different groups of students, error analysis, study of attitudes, remedial teaching methods, socio-economic and other personal factors influencing learning.

Banerjee (2012) stated that one of the major challenges that India faces in developing mathematics education as a research area is the lack of systemic support. The university departments and colleges of education have not been able to provide the space and support for establishing traditions of content specific and subject specific research with sound theoretical frameworks and well-designed empirical studies. This is also due to the fact that education departments are isolated from departments of subject disciplines, like mathematics, which can provide inputs on the content aspect in mathematics education research. The studies conducted in the departments still follow the traditional style of research with focus on psychometric designs, studies on lists of errors in different areas, studies in the area of fear and anxiety in mathematics, nature of mathematics and its pedagogical implication. There is an acute shortage of experienced faculty/researchers across the country, who can take up research issues in mathematics education as well as contribute effectively to teacher education programmes. There is no systemic structure to support and strengthen such work.

1.7 Review of related literature

Researchers in different countries have often been studying the subject of Mathematics Education in different aspects. At the Schools, College and University level, different researchers had unique findings in mathematics education. Research in mathematics education has mostly been confined to curriculum, teaching strategies, determining the state of knowledge in mathematics education and ICT used in the teaching and learning of mathematics. The findings of these researches have definitely influenced Mathematics Education in many positive ways. They also provided answers to some unresolved problems in the teaching and learning of mathematics.

Hennessy et al (2001) investigated teachers' and students' changing roles and strategies in the context of using various forms of computer-based information and communication technology to support subject teaching and learning at secondary level. One hundred and fifteen teacher researchers participated in a collaborative programme of small-scale, classroom-based projects involving development, evaluation and refinement of new pedagogic approaches, strategies and activities in six curriculum areas. An analysis was conducted across the case study data derived from lesson observations; follow up teacher interviews and teachers' written research reports. While interactions with individual students and small groups were increased and reportedly successful, mediating interactions between students and technology through whole-class interactive teaching, modeling and discussion appeared to be under-developed.

Mulqueen (2001) emphasizes that teachers need to be the center of any technology development program. That is, teachers' assessments of a program need to be taken seriously, valued, and respected. Creating an effective professional development program can only be accomplished by heeding their suggestions and implementing their recommended changes.

Strehl, et.al (2001) found that there exist a match between use of technology and instructional goals. Second, technology integration was complicated and difficult. Third, through the narratives and study groups, they were able to offer support to one another and learn new pedagogical approaches.

Clements (2002) reviews research on young children's mathematical learning in conjunction with various forms of computer-mediated practice including the use of drill-and-practice mathematical software, and the exploration of shapes, patterns, and numerical relationships using general purpose graphics programs, or specialized "computer manipulative" programs in which children are able to perform specific mathematical transformations on objects on screen. Clements concludes there is evidence that computers can assist even very young children to develop mathematical ideas, provided teachers are able to choose and use these tools in a way that scaffolds and extends young children's thinking, in particular, their higher-order thinking. Unique advantages of computers for fostering higher-order thinking include: allowing children to create, change, save, and retrieve ideas; promoting reflection and engagement; connecting ideas from different areas, such as the mathematical and the artistic; providing situations with clear-cut variable means-end structure, some constraints, and feedback that students can interpret on their own; and so allowing children to interact, think, and play with ideas in significant ways.

Allan, H.K. et al (2003) reporting the findings of an analysis on models of change in 18 schools striving to integrate the use of ICT in teaching and learning across the school curriculum, showed that the strategy adopted by a school in instituting such a change and resulting variation of pedagogical practices using ICT is strongly dependent on the school leaders' vision and understanding of the role and impact of ICT in the curriculum, their goals and objectives for ICT integration, as well as the history, culture and background of the school and its general vision and mission.

Osborne, J. and Hennessy, S (2003) reviewing the current state of science education, the impact of ICT use on the curriculum, pedagogy and learning and the implications for future practice, considered how ICT can be employed flexibly to support different 34 curricular goals and forms of pedagogy. They revealed that there are diverse ways of linking ICT use to existing classroom teaching, including supporting or replacing it, suggesting further that transformative use of ICT in science is found only in isolated pockets as technology is not yet embedded in the culture and practice of many science teachers. They hinted that the content oriented National Science Curriculum hindered the development of classroom use of ICT, but as the science curriculum moves towards a greater emphasis on scientific reasoning and analytical skills, there would be more opportunities for ICT to play a key role in Science Education.

Passey et al (2003) aiming to identify and, where possible, to quantify impact and to relate it to aspects such as learning outcomes, behavior, school attendance, truancy, anti- social behavior and uses of digital content, found that ICT helped to draw pupils into more positive models of motivation and could offer a means by which pupils could envisage success. All of the secondary school teachers involved felt that ICT had a positive impact on pupil interest in and attitudes to school work. Pupils took greater pride in their work and it was more likely that tasks were completed and on time. The study drew on a range of theoretical stances, problematizing the concept of motivation and identifying a number of different dimensions. The study also found that, when working with ICT, pupils learning was characterized by high levels of motivation towards achieving personal learning goals – a desirable outcome – but also high levels of motivation towards gaining positive feedback on individual competence (performance approach goals) -which was less desirable.

Becta (2003) investigated the relationship between ICT resources and pupil attainment in primary and secondary school and found a consistent trend for pupils in schools with better ICT resources to achieve better grades for English, Mathematics and Science. More than half of the schools with very good ICT resources were achieving above the national standards in science, compared with less than a third of schools with ‘poor’ ICT resources. There were similar results for English and Mathematics. Schools with very good ICT resources were found in a similar range of social contexts as schools with poor ICT resources. It concluded that any difference in standards and attainment levels between the two groups of schools is not due to socio-economic factors. This 32 report is based on an analysis of the inspection results for the 2,500 primary school inspected in the year 1998-99.

Mouza (2002) provides insight into the factors influencing teacher technology use and provides suggestions for technology professional development that can be applied to other programs. A triangulated case study methodology of three teachers was employed in order to gain an in depth understanding of the constructs involved in effective technology professional development. The author conclude that technology professional development should involve teachers in a variety of activities, such as modelling, discussions, brainstorming of ideas, hands-on practice, and just-in time support.

Valentine et. al (2005) found that parents and pupils believed that ICT improved motivation and confidence, made school work more enjoyable and improved achievement. They reported a statistically small improvement in attainment in Mathematics and English linked to the home use of ICT for educational purposes at particular key stages, and concluded that home use brings advantages in terms of new sources of information, enhanced presentation and raised self-esteem which, in turn, affects attainment.

Jung (2005) identifies the approaches for ICT-pedagogy integration in teacher education by analysing the cases worldwide. Four main approaches suggested are ICT use as main content focus of teacher training, ICT use as part of teaching methods, ICT as core technology for delivering teacher training and ICT used to facilitate professional development and networking. He also identified the practices happening worldwide under each approach. The analysis of the study reveals that in many cases, the national vision for the use of ICT in education has been integrated into teacher training. For example, Singapore's teacher training institute has successfully integrated the national vision toward the use of ICT in education into its ICT plan. Other countries such as UK, USA, South Africa, Sweden and Korea have developed extensive online resources and encouraged active exchanges of new pedagogical ideas to upgrade teachers' knowledge and skills at the national or international level. It is also observed from the analysis that a variety of ICT-integrated training environments have been created to provide more effective ICT training. As indicated above, teachers tend to integrate ICT in their teaching if they experience ICT skills as a learner. Teacher training approaches in this study show that many cases adopt ICT into their training process not just as content of the training but rather as an integrated training environment and thus allow teachers to experience ICT-based pedagogies. It suggests for more hands-on experiences that relate ICT to the achievement of wider pedagogical objectives at the initial training level and at the advanced level, the provision of opportunities for teachers to produce and disseminate ICT-based instructional materials is also recommended. The study insists that a well-designed teacher training program is essential to meet the demand of today's teachers who want to learn how to use ICT effectively for their teaching. It suggests for more attention to be paid to specific roles of ICT in offering multimedia simulations of good teaching practices, delivering individualized training courses, helping overcome teacher isolation, connecting individual teachers to a larger teaching community on a continuous basis, and promoting teacher-to-teacher collaboration.

Chong, et. al (2005) study the barriers preventing the integration and adoption of information and communication technology (ICT) in teaching mathematics, identified six major barriers, that is lack of time in the school schedule for projects involving ICT; insufficient teacher training opportunities for ICT projects; inadequate technical support for these projects, lack of knowledge about ways to integrate ICT to enhance the curriculum; difficulty in integrating and using different ICT tools in a single lesson; and unavailability of resources at home for the students to access the necessary educational materials. To overcome some of these barriers, it proposed an e-portal for teaching mathematics. The e-portal consists of two modules: a resource repository and a lesson planner. The resource repository is a collection of mathematical tools, a question bank and other resources in digital form that can be used for teaching and learning mathematics. The lesson planner is a user-friendly tool that can integrate resources from the repository for lesson plan.

Balarabe (2006) studied the influence of blended e-learning on students' attitude towards mathematics and computers. The study indicates that the students have positive attitudes towards mathematics and computers. However, analysis of variance shows no statistically significant change in students' attitudes towards mathematics and computers except for computer, confidence and anxiety scale.

Barak (2006) joins several other researchers (Buettner, 2006; Ottevanger et al. 2007) in their study questioning the efficacy of teacher preparation for the successful application of ICTs in school classrooms. They argue that the quality of teaching depends on the way teachers were taught and hence the teacher education programs treating ICT as a separate phenomenon of study will probably result in the unimaginative subsequent integration of technology into the school curriculum.

Neera (1994) comparing effectiveness of Video Teaching Learning Material (VTLM), Video Aided Instruction (VAI) and Conventional Teaching (CT) found students most favorably disposed towards VTLM. Retention with VTLM and VAI was more effective than CT. Students exposed to VAT retained more than that through conventional approach. Students exposed to VTLM and VAI were significantly different in their achievement.

Meera, S (2000) found out whether there is any significant difference between the Conventional Lecture Method and the Computer Assisted Instruction (CAI) as an individualized Instructional strategy in terms of their effectiveness in realizing the instructional objectives in Biology at Class Xl. The achievement test revealed that the use of different modes of Computer based Instruction viz. Drill, Practice and Simulation was more effective than conventional lecture method in realising the instructional objectives in Biology at Class XI as well as in enhancing the retention of cognition of what have already learnt as revealed by the learner's performance in the retention test.

Natesan, N (2001) compared the effectiveness of teaching concepts in mathematics through video-cassette with that of traditional method. Experimental method (equivalent group design) was adopted for the study. The sample taken was 45 boys and 45 girls, using probability sampling for the study. Findings of the study revealed that the increased level of academic achievement of experimental group was due to the teaching of Mathematical concept through video-cassette.

Subbaiah, S (2005) investigated the application of information and Communication technology in teacher education with reference to certain selected variables and to identify the information and communication technology needs, knowledge and skills among the teacher educators. The sample was taken from 29 District Institutes of Education and Training in Tamil Nadu. 71 English teacher educators and 200 teacher trainees were selected using probability sampling method for the study. Questionnaires, Attitude scale, Interviews, Diary analysis were used as data collection tools. It revealed that the focus of computer equipment problem had both quantity problem (not enough computers) as well as quality problem.

Shankar, S. P. and Subasri, J (2006) analyzed accessibility of PowerPoint presentations among the high and higher secondary school teachers in classroom teaching in selected schools of Pondicherry state. The total sample size of the study was 80 teachers, with different age groups, gender, educational qualifications, specializations, computer knowledge and viability area and school. The study was done at random in selected government and private schools in Pondicherry state. For data collection, a questionnaire was provided to all respondents. Findings of the study revealed high significant relationship between the fundamental knowledge of computers among the teachers and PowerPoint accessibility in classroom teaching. The level of adaptability towards PowerPoint utility in classroom teaching was found to be more with the science teachers when compared to that of the teachers teaching Arts subjects. There was no significant difference between the high school and higher secondary school teachers in using the PowerPoint presentations in classroom teaching.

Mehra (2007) study to determine the attitudes of school teachers towards use of computer technology for instructional purposes on a sample of 200 government senior secondary school teachers of Chandigarh, revealed that teachers possessed fairly positive attitude towards computers uses, but majority of teachers needs to be provided training for using computers in instructional settings.

Anjali (2008) exploring the relevancy of ICT in education with a special focus on teachers' training Multimedia Package for laboratory method in teaching of chemistry at pre-service level developed by the researcher and tried on sample of 18 B.Ed. students of the year 2005-06 batch offering teaching of chemistry as a method, revealed effectiveness of the developed multimedia package in learning the concept of management of chemistry laboratory over the conventional approach.

Bakar and Mohamed (2008) studied the relationship of confidence with ICT integration. Trainee teachers were quite confident with their ability to integrate ICT training teaching. Male trainee teachers were more confident with the ability to integrate ICT in teaching. Trainee teachers who had taught in schools felt more confident with their ability to integrate ICT in teaching Vocational trainee teachers felt more confident with their ability to integrate ICT in teaching. There is no significant correlation between academic performance and levels of confident in the integration of ICT in teaching.

Nouri, H. and Shahid, A (2008) conducted a study to explore whether providing lecture notes when PowerPoint is used for class presentation affected student performance and attitudes toward instructor. This study was conducted in a classroom setting throughout the semester. The experiment involved two sections of an Accounting Principles I course.

Choudhury, R (1999) observed that mathematical literacy is indispensable for a person to be regarded as educated. Everybody needs mathematics in one form of another tool for physical science but a language for all disciplines. The factors, Arithmetical Ability, Interest in Mathematics (IIM), IQ and Sex of the pupils are significantly co-related with their Achievement in Mathematics (AIM). Pupils Achievement in Mathematics (AIM) is influenced significantly by their Achievement in Arithmetic (AIA). Pupils Achievement in Mathematics (AIM) is affected significantly by their Interest in Mathematics (IIM). IQ is a highly influential factor in relation to pupils' performance in mathematics. Sex is found to be a influencing factor regarding performance in mathematics of low boys and low girls. The topics "stocks and dividends', 'discount' and 'banking' which are included in the course content of the pupils are responded as "very difficult" topics by majority of the students. Performance of the pupils in the Arithmetic Ability Test is found to be very poor; they are lagging behind in numerical literacy. Pupils' concepts on decimals, percentage and magnitudes of negative and fractional numbers are found to be not clear.

Bergqvist, Holmquist & Lingefjard (2001) found that scientific calculators, graphic calculators and other useful software are beneficial for teaching and learning of mathematics. **Becta (2003)** suggested that teachers have to utilised the ICT in mathematics teaching, developed knowledge of relevant softwares and multimedia and incorporate convenient ICT equipment in their teaching practices. CAS, Logo, Mathematics Curriculum Software, Dynamic Geometry Systems and Interactive Whiteboard were also effective tools for the teaching of mathematics.

Butler (2005) highlighted that many software have been developed like Graphing Calculator, Dynamic Algebra System, Dynamic Omni Graph Evaluation, Calc 3D Pro, Graphers, Cinderella 2 and so on related to the teaching and learning of mathematics.

Aydın (2005) mentioned that Logo, Excel, Computer Algebra System (CAS), Word Processing and Database are general applications for mathematics and Mathematica, Even Derive, MatLab, MathCad and Maple are included under CAS. **Keong, Horani & Daniel (2005)** highlighted some software used by Mathematics teachers were spreadsheets, word processing packages, presentation software, drill and practice software, and search engines.

Bhattacharya and Sharma (2007) advocated that ICT help in the creation of digital resources like digital libraries where students, teachers and professionals can access research material and course material from any place at any time. **Drews (2007)** suggested some potential resources for mathematics teachings as ICT, images, mathematical games, textbooks and worksheets. **Anthony & Walshaw (2009)** advocated that appropriate technological tools should be manage in the mathematics classroom like calculator, computer applications, internet, presentation, mobile and digital technologies.

Agyei & Voogt (2010) recommended that in the school curriculum, ICT should be integrated. **Goos (2010)** found that ICT is very useful for numerical calculation, graphic representation and also to give concept of geometric figure during mathematics teaching and learning period.

NCETM (2010) mentioned some useful software for the teaching of secondary level mathematics like Adobe (or another) SVG Viewer, Acrobat Reader, Bowland Mathematics Materials, Animation Software, Digital Image Manipulator such as Picasa, Data Logging Software, Equation-Editor as FX-Maths Pack, Drawing Program, Internet Based Programs (EXP Maths 7, 8 and 9, java, Flash, Shockwave), Geometry related software (GeoGebra, Geometer's SketchPad), Google Earth, Formulator Tarsia, graph drawing package (Omnigraph, Autograph, GeoGebra), Interactive Whiteboard Software, graphic calculator, Mathematica Player, Internet Browser (Plus Anti-Virus, Firewall, Anti-Spy-Ware Software), Media Player, Photograph and Music Compilation Software, Spreadsheet, Sound and Audio Editor, TV access, Statistics Software (Autograph, Fathom, Tinkerplots), Virtual Manipulatives, Video Conversion Software, YouTube and Word Processor.

Safdar et al (2011) found that using software, algebraic expression, sets and logarithm can be taught effectively. **Kaur (2011)** suggests that the student-teachers should be given all the opportunities, resources and facilities to learn to use different ICT tools during the course before their teaching practice, special sessions should be arranged for student-teachers at university to show them various methods to incorporate technology in their teaching, the teaching practicum should be planned in such a way so that all the student-teachers get equal opportunity to teach in schools which support ICT, and have all the resources available and the efforts made by student-teachers to incorporate ICT in their teaching should be considered in their assessment.

Livingstone (2012) found that ICT can improve the quality of teaching, learning and management in schools. **Hazarika, B.B (2013)** found that no significant difference between mean 'mathematics interest' score of male and female students of government SEBA schools. Significant difference between mean 'mathematics interest' score of male and female students of private SEBA schools. No significant difference between mean 'mathematics interest' score of male and female students of private CBSE schools. No significant difference between mean 'mathematics interest' score of male and female students of different categories of schools.

Fulbrighter (2013) stated that probes, camera/video, Smartphone, loudspeaker/ microphone, tablet/iPad, classroom response system, chalk/marker, document camera, projector, interactive whiteboard, computer and calculator are ICT based instructional materials for the teaching of science and mathematics. **Mirazchiyaski (2014)** found that mathematics software provides a new opportunity to teachers for better teaching in mathematics.

Pachemska et al (2014) investigated that in ICT applied class, mathematics achievement of students were significantly higher. **Granberga & Olsson (2015)** found that GeoGebra software support students' collaboration as well as creative reasoning in solving mathematical problem. **Lu, Tsai & Wu (2015)** investigated that video enabled classrooms, preparation rooms for e-lesson, micro-teaching classrooms and Interactive-Whiteboard for the teaching methods training become popular.

Lalremmawii (2015) found that male mathematics teachers occupy a higher percentage than female mathematics teachers in secondary schools. Mizo students in secondary schools are weak in mathematics subject. Private secondary schools showed better performance in mathematics subject than Government secondary schools mathematics students. Gender did not play much role in the understanding of mathematics subject at secondary levels. Both genders have higher percentage in the lower level of performances whereas they also have less percentage in the upper level of performances.

Lalduhawma (2015) found that mathematical modeling encourages a deeper knowledge of mathematical ideas and trains student to reflect, interpret, and formulate a plan when presented with a non-traditional problem. **Lalduhawma (2018)** also found out that students were excited about the ICT training programme for mathematics learning and they wanted to attend more such training in their future and suggested that teachers should try to motivate the students at the beginning and use Information and Communication Technology based methods as far as possible.

Zakaria and Khalid (2016) found that the advantages of applying ICT in teaching mathematics are: It attracts students' interest in learning mathematics; it increases their motivation and performance; it encourages lifelong learning; and it facilitates positive interactions and relationships.

Joshi (2017) concluded that ICT supports mathematics teacher for their design of lessons, teaching learning tactics, updated to subjective and pedagogical knowledge and expansion of other several relevant skills. It is also highly beneficial for students to stimulate and involve in learning, assembled confidence in their mathematical capabilities, share and develop several subjective ideas and others and all related stakeholders should have facilitate and encourage them for its proper utilization in teaching learning activities and suggested that every teachers and students should extremely utilize it in their teaching learning activities. **Das (2019)** found that ICT integration in Mathematics-education has a positive impact on both the teaching and learning process.

Lalremmawii (2021) found that significant difference was found between government and private secondary school students in mathematics subject during the year 2015-2019. Majority of secondary students had negative attitude towards mathematics subject. No significant difference was found between urban and rural schools in the attitude of secondary schools students towards mathematics subject in Mizoram.

Namome and Moodley (2021) found that student access to ICT during a lesson was significant and a positive predictor for student learning outcomes in mathematics. But teachers still lack current ICT skills to blend with pedagogy and they recommended bridging this gap by providing technical support and consistent ICT training to teachers. Student who can access ICT at home had a significant positive influence, having more ICT skills and were associated with higher learning outcomes and they recommended that parents/guardians should provide educational ICT devices and programs to students.

A review of literature related to the study of mathematics education was done by the scholar in order to know more about the status of researches done and also to understand the findings of other researchers on the topic. Many researches works show that ICT is very useful for effective teaching and learning of mathematics. The investigator thought that in order to find solutions to a number of problems and also to seek better plans and programs for mathematics education within the state of Mizoram, a proper knowledge of the use of ICT was necessary and knowledge of the effectiveness of ICT in teaching and learning of mathematics in Mizoram may help the policy maker and concerned authority for the improvement of mathematics education in the state. Therefore the investigator decided to go for the present study as to further enrich the already present knowledge and to contribute more data to the existing one.

1.8 Rationale of the study

Mathematics education is a vital concern although only limited research is available for studying this topic particularly in Mizoram. It is the root of all sciences and technical education, and it also has its own merit in real life. However, there is general opinion even among the intellectual circle in Mizoram that - Mathematics subject is the backlog for many students to succeed in academic, convincing themselves that one can succeed in life without Mathematics at the secondary level. The 63rd meeting of the Syllabus and Textbook Committee of MBSE held on 5th July, 2011 in its resolution no. SC:63:2011:06 decided that two levels of Mathematics i.e. Group A and Group B be introduced in the classes IX and X, whereby only those students who opt for Group A Mathematics would be eligible for Science stream when pursuing higher studies. This was felt important because there are a number of students failing in the subject or who barely managed to make through HSLC, but never have any link with Mathematics for their further studies.

Although the Education Commission, 1964 recommended that Mathematics should be taught as a compulsory subject of general education up to class X, experiences and data have shown that the majority of students normally failed in this subject. This frustrates not only students but also parents. Many educationists feel that Mathematics should be compulsory up to class VIII, while some opine that there should be two types of Mathematics courses at secondary level, and these courses should be need-based. Central Board of Secondary Education (CBSE) has decided to introduce two levels of examination in Mathematics for the students who are going to appear in the Board examination for the academic session ending March 2020 onwards. One will be known as Mathematics - Standard, for the existing level of examination, and the other will be known as Mathematics - Basic, for the easier level of the exam (for students who do not want to study Mathematics in future).

NCERT (2006) identified that there is a sense of fear and failure regarding mathematics among the majority of children and there is lack of support in the teaching of mathematics. The paper stated "By Class III or IV, many children start seeing them as unable to cope with the demands made by mathematics. In high school, among children who fail only in one or two subjects in year-end examinations and hence are detained, the maximum numbers fail in mathematics. This statistic pursues us right through to Class X, which is when the Indian state issues a certificate of education to a student. The largest numbers of Board Exam failures also happen in mathematics".

Devi (2004) found out that most students have no interest in learning mathematics which reflected the result of HSLC Examinations.

Zohmingliani, L and Lalremmawii, C (2020) found out that secondary school students performance in Mathematics has been consistently poor and suggested that more research needs to be taken up for finding out the problems of students with regards to Mathematics, more efforts should be given for the development of mathematics education and the state government needs to pay special attention for the development of mathematics education.

The findings of the present research work are expected to be of much value to all stakeholders of education, especially at secondary education. These data analysis and finding will be of extreme importance to teachers, policy makers, administrators, examination boards and syllabus framers alike.

1.9 Statement of Problem

It is a great concerned to the society as a whole to improve the teaching-learning of Mathematics to achieve greater result and better understanding of the mathematical concept. In order to improve mathematics education in Mizoram, urgent steps are needed to be taken.

Therefore, it is important to find out the performance of students at secondary level, which is the end of **c**omprehensive education where official data were maintained by the MBSE. Practical and feasible suggestion for the improvement of Mathematics Education is also the immediate need in school education in Mizoram.

ICT has integrated several streams for secondary education in Mizoram. Computer education is a separate additional subject in secondary school curriculum (class 6 to 10). Mizoram Board of School Education (MBSE) also integrated ICT in different subjects at intermediate level.

Several researches can be found in the field of education which provides the ideas for policy making, designing of curriculum, selection of appropriate pedagogical methods, and selection of teaching instruments, school management techniques and so on. However, only a few researches can be found in the use of ICT in mathematics education. In the context of Mizoram, there is no such research in the use of ICT in mathematics education.

In view of the problem faced by students and teachers in the teaching and learning of mathematics in Mizoram and to give responds to a number of questions regarding the study of this subject, the present study may be stated as **"Effectiveness of ICT in Mathematics Education in Mizoram".**

1.10 Research Questions

In order to have a reliable solution to the problem stated, the following questions emerge as the most important questions that need urgent answers

1. Among all the subjects, is Mathematics the subject in which the students have the worst performance in the HSLC Examinations conducted by MBSE since inception?

2. What is the interrelationship between the score of Mathematics and other subjects in the HSLC Examinations?
3. What are the availabilities for using ICT and the barriers for effective ICT use in the schools of Mizoram?
4. Will the use of ICT improve the quality of teaching and learning of Mathematics in secondary schools of Mizoram?

1.11 Objectives

In order to answer the research questions, the following objectives are formulated:

1. To collect dataset from Mizoram Board of School Education (MBSE) to study the subject wise performance of all the candidates in the Board examination since inception.
2. To analyse the data collected using statistical tools.
3. To study the effectiveness of the use of ICT for learning mathematics at school level.

1.12 Methodology

The method adopted for the present research is field study and collection of relevant data from government records questionnaire, opinionnaire, books, journals and web contents.

In field study, mathematical software like Geogebra etc. are used to students within the target group to find out the effectiveness of ICT in Mathematics teaching and learning.

The collected data was analyzed and studied using suitable statistical tools such as percentage, mean, co-relation, regression, χ^2 test, T-test etc. Suitable statistical softwares like SPSS, Excel etc. will be employed.

In mathematical statistic tests, the probability distribution of the statistics is important. When samples are drawn from population N (μ, σ^2 /n) with a sample size of n, the distribution of the sample mean $\underline{X}$ should be a normal distribution N (μ, σ^2 /n). Under the null hypothesis $\mu = \mu_0$, the distribution of statistics $z = \frac{\underline{X}-\mu_0}{\sigma/\sqrt{n}}$ should be standardized as a normal distribution.

When the variance of the population is not known, replacement with the sample variance S^2 is possible. In this case, the statistics $z = \frac{\underline{X}-\mu_0}{\sigma/\sqrt{n}}$ follows a *t*-distribution (n-1 degrees of freedom). An independent-group *t* test can be carried out for a comparison of means between two independent groups, with a paired t test for paired data. As the t test is a parametric test, samples should meet certain preconditions, such as normality, equal variances and independence.

There is the independent t test, which can be used when the two groups under comparison are independent of each other, and the paired t test, which can be used when the two groups under comparison are dependent on each other.

T tests are usually used in cases where the experimental subjects are divided into two independent groups, with one group treated with first group and the other group treated with second group.

The χ^2 test: This test is distribution free testing method, commonly used in non-parametric test. The quantity (χ^2) describes the magnitude of the discrepancies between theory and observation.

The formula of χ^2 test is given by $\chi^2 = \sum \frac{(O-E)^2}{E}$ where

$O -$ observed frequency and

$E -$ expected frequency.

The expected frequency (E) can be calculated as $E = \frac{RT \times CT}{N}$, Where

$RT -$ the row total for the row containing cells,

$CT -$ the column total for the column containing cells and

$N -$ the total number of observations.

The degrees of freedom of the χ^2 test is also given as $\nu = (r-1) \times (c-1)$ where r is number of row of the observation matrix and c is the number of column of the observation matrix.

1.13 Operational Definitions of the Key terms used

Effectiveness:	Capability of producing a desired result or the ability to produce desired output.
Mathematics Education:	The practice of teaching and learning mathematics, especially in formal education.
Mizoram:	The name of one of the states in India, the name is derived from "Mizo", the self-described name of the native inhabitants, and "Ram" means "Land" in English. Thus "Mizoram" means **"Land of the Mizos"**
School Education:	The level of education up to class 12.
Elementary Education:	The level of education up to class 8.
Secondary Education:	The level of education from classes 9 to 12.

CHAPTER 2

ANALYSIS OF HIGH SCHOOL LEAVING CERTIFICATE (HSLC) EXAMINATION RESULTS UNDER MIZORAM BOARD OF SCHOOL EDUCATION (MBSE) FROM THE YEAR 1978 TO 2021 AND FORECASTING MALE AND FEMALE PASS PERCENTAGE

In this chapter, we will discuss the relationship of Mathematics subjects and other subjects in the HSLC examinations conducted by MBSE using mean, percentage, correlation and regression analysis, the mean score for each subject for the years 1978 to 2021 was calculated using simple arithmetic mean, the degree of relationship between Mathematics score and other subjects using correlation coefficient. At last, a time series analysis was engaged to forecast the pass percentage of male and female candidates for the next five years 2022-2026 and also identify the appropriate model to be used. SPSS 20 was employed for data analysis.

2.0 Introduction:

Matriculation Certificate, also called the High School Leaving Certificate is a certificate awarded for students who have cleared their class 10 or 10^{th} grade examinations. Many countries around the world have their own set of examinations for class 10 or higher. In India, this examination is conducted by various boards - such as the CBSE, ICSE and State Boards. Matriculation examination are one of the most important exams in India as the number of seats for class 11 are usually lower than the number of seats in class 10. Moreover, clearing this particular exam is extremely important in India as it is considered the gateway to all other future opportunities – irrespective of career or academics. For instance, if students wish to enroll in any ITI course, clearing the class 10 exam is the minimum educational requirement. The same applies if students wish to precede with their class 11, 12, or any other courses. The term matriculation has been borrowed since the days of British rule in India. In England, the term matriculation is now replaced with the “O” Level or the Ordinary Level Examination. English is the standard language for matriculation for science subjects, while regional languages are also an option. Most students who pass matriculation or class 10 are 15–16 years old. Upon successfully passing, a student may continue their senior secondary school. Most students who pass class 12 are 17–18 years old. The CBSE and ICSE boards conduct twelfth standard courses nationally, while state boards operate at the state-level. Although the basic curriculum is prescribed by the CBSE, quality of education varies according to the school and region.

The Mizoram Board of School Education was established in 1975 by the MBSE Act. The act was approved by the Legislative Assembly of the Mizoram Union Territory, at that time the administrative head was the Chief Minister Ch.Chhunga. The board, as an autonomous authority in education started functioning on 2nd December 1976. It has the power to regulate, supervise and control school education in Mizoram. Its primary function is to prepare academic programs and organize examination, especially for state level HSLC and HSSLC. The first HSLC examination was conducted by MBSE in 1978. As in 1978, pass percentages for male and female were 37.18% and 26.48% respectively. In 1992, the pass percentages for both male and female were 46.07% and 46.98% respectively and in 2021; the pass percentage for both male and female were 80.03% and 83.51% respectively.

2.1 Pass percentage and Subject-wise performance of students in HSLC Examinations

The MBSE conducted its first HSLC Examination in 1978. The MBSE maintained soft copy of candidate’s mark detail up to 2005. Prior to 2005, the score records of the candidate’s were kept in the tabulation sheet. With the supervision of MBSE officials, mark records prior to 2005 were entered by a group of data entry operator during 2021. Then, the researcher requested the data in writing to the MBSE authority, and was provided all the data of 43 HSLC main examinations, excluding candidate’s personal detail like Name, Roll No. etc., from the year 1978 to 2021 in MS excel 2010 sheet by the MBSE (MBSE, HSLC Results, 1978-2021).

Figure 2.1: Photo of Data Entry Operators entering HSLC marks at MBSE Office

Table 2.1: Year-wise Result of HSLC Examination under MBSE from 1978-2021

Year	Name of Examinations & Months	No. of Candidates appeared	No. of pass	Main Exam %	% after incorporating the results of Supp. Exams
1978	New Course (March & April)	1975	882	38.93	44.66
1978	Old Course (March & April)	2853	1438	32.74	50.33
1979	New Course (March)	2755	1016	36.00	36.87
1980	New Course (March)	3327	1426	38.17	42.86
1981	March	3740	1901	44.03	50.83
1982	March	4445	1912	39.05	43.01
1982	December (Spl)	2267	843	37.19	
1983	March	2169	1030	47.00	47.48
1984	March	3652	1145	31.95	
1984	December	4934	1853	37.56	37.56
1985	Nov & Dec	4533	1908	39.55	42.09
1986	Nov & Dec	5013	1827	34.13	36.45

1987	Nov & Dec	6427	2551	38.10	39.69
1988	Nov & Dec	6195	2724	37.38	43.97
1989	Nov & Dec	7679	2556	30.45	33.29
1990	Nov & Dec	8227	3021	32.27	36.72
1991	Nov & Dec	9567	4334	37.12	45.30
1992	March	14574	8042	49.71	55.18
1993	New Course	5258	1464	26.91	27.84
1993	Old Course	4697	887	48.52	18.88
1994	New Course(Feb)	8333	2747	29.69	32.96
1994	Old Course	1871	444	23.73	
1996	February	8591	2739	25.29	31.88
1996	December	8173	3063	30.25	37.48
1997	December	8312	4807	34.22	57.83
1998	December	9171	4551	41.08	49.62
2000	February	11660	4906	34.87	42.08
2001	Feb-March	11411	5452	42.18	47.78
2002	Feb-March	13740	6686	43.58	48.66
2002	Special (Nov)	5549	3029	42.80	54.59
2003	March	7150	2353	30.95	32.91
2003	June (Spl)	1260	545	43.25	
2004	March	11414	4470	29.98	39.16
2005	March	12562	6819	45.77	54.28
2005	December(Spl)	3690	1273	34.50	
2006	January	8787	4166	40.49	47.41
2006	December (Spl)	816	507	62.13	
2007	Feb-March	11401	6496	51.46	56.98
2008	February	12209	8171	62.40	66.93
2009	February	12714	8002	60.46	62.94
2010	February	14652	9940	66.60	67.84

2010	September (Spl)	3427	2255	65.80	65.80
2011	Feb-March	11025	7858	69.99	71.27
2012	Feb-March	15206	11173	72.27	73.48
2013	Feb-March	16144	9597	58.63	59.45
2014	Feb-March	18469	12630	67.51	68.38
2015	March	17157	11825	68.30	68.92
2016	March	17462	12837	71.17	73.51
2016	August (Special)	3471	2028	58.43	
2017	March	14628	10647	72.17	72.79
2018	March	17695	14098	76.65	78.22
2019	March	17346	11949	67.93	68.89
2020	March	18036	12393	68.33	68.71
2021	April	18012	14847	82.43	83.32

Source: Mizoram Board of School Education

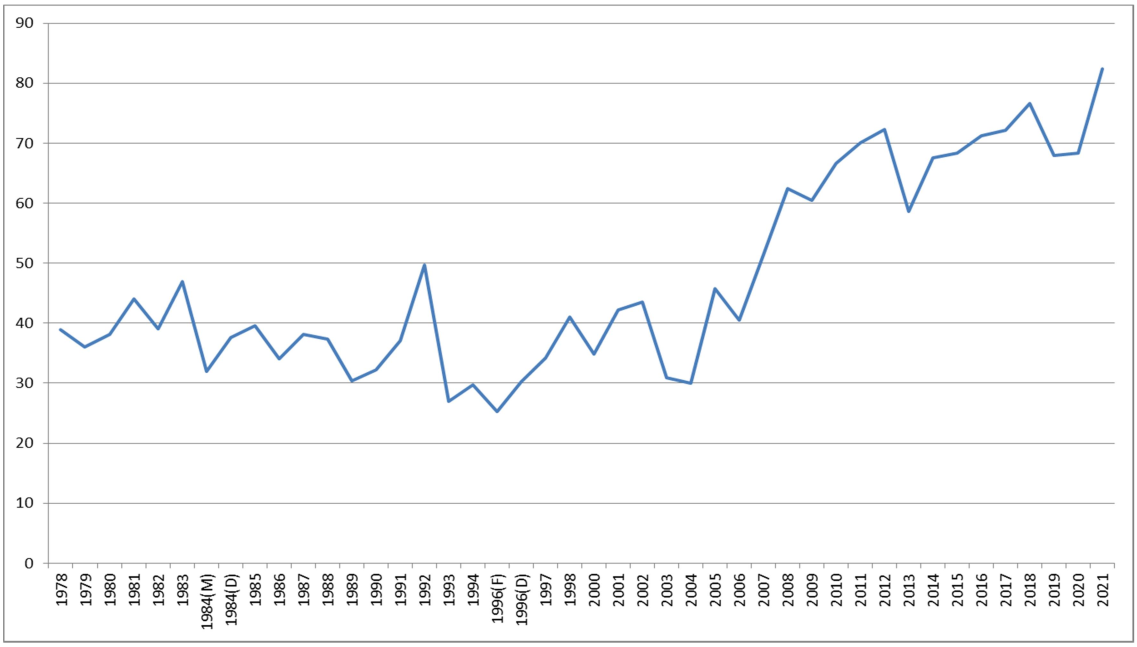


Figure 2.2: Pass percentage of HSLC examinations under MBSE from 1978-2021

Figure 2.2 shows pass percentage of HSLC main examinations (excluding special, supplementary and compartmental examinations). From 1978 to 2006, pass percentage is below 50%, which means that more than half of the candidates did not pass the HSLC examination. It was generally said that these failure are mainly due to Mathematics subject. From 2007, we can see a new trend, pass percentage increased gradually and it was always above 50%. In 2021 HSLC examination, pass percentage was 82.43%, which is the first time it was more than 80%. This may be due to reduction of course by 30% from the full syllabus due to covid-19 pandemic. From 2008 onwards, pass percentage is above 60% except in 2013.

Mathematics subject was included in the HSLC Examinations from the beginning with subject name "General Mathematics" with 100 as full marks and 30 as pass marks. From 1983, the name of the subject was changed to "Mathematics" with 150 as full marks and 53 as pass marks. MBSE had changed scheme of examinations as and when it feels necessary during the study period, where full marks and pass marks were also affected. In all the examinations where full marks is not 100, the researcher converted the score of each candidates out of 100 and so, the score of all the year under study are calculated out of 100. To find mean score, all the score in each subject were sum up using Excel software's and then divided by the number of candidates appeared in the examination in that particular subject to obtained the mean score. Pass percentage in each subject was calculated by counting number of pass in each subject as per pass marks of the subject and using number of candidates appeared in that examination.

From figure 2.3, it can be seen that out of 43 HSLC Examination conducted by MBSE since inception, the mean score of HSLC candidates is lowest compared to other subjects in 35 examinations, Social Studies in 5 examination, Science in 1 examination and English in 2 examinations. This shows that Mathematics score of the candidates is lowest in almost all the HSLC Examinations conducted during 1978 to 2021.

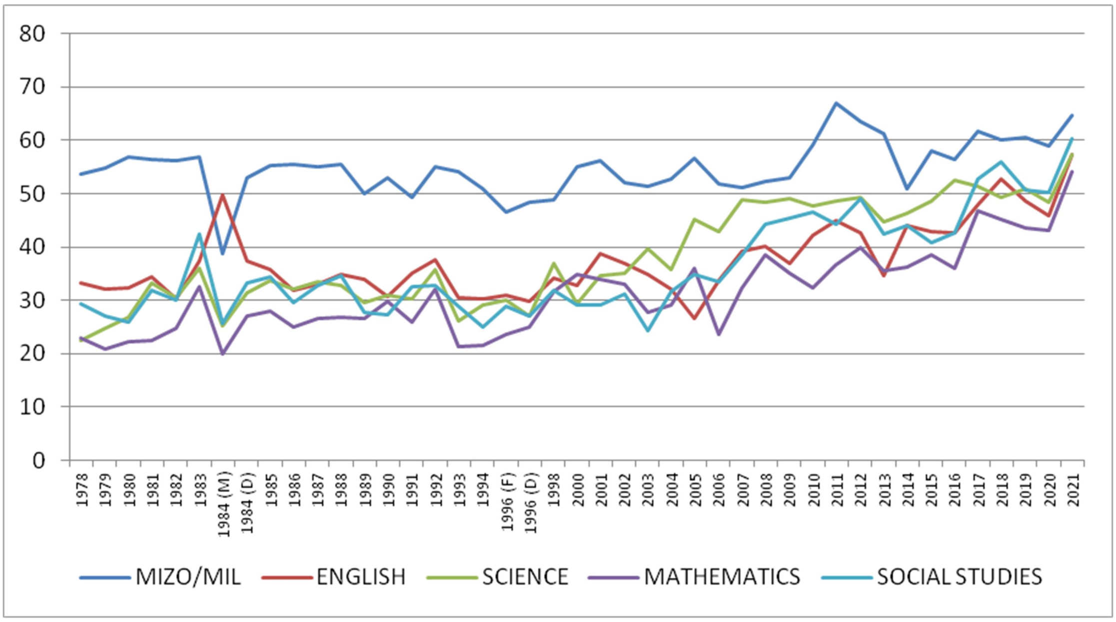


Figure 2.3: Subject-wise mean score of HSLC candidates under MBSE from 1978-2021

From figure 2.4, it can be found that out of 43 HSLC Examinations conducted by MBSE so far, the pass percentage of HSLC candidates in Mathematics subject is lowest compared to other subjects in 31 examinations, Social studies in 6 examinations and Science subject pass percentage is also lowest in 6 examinations.

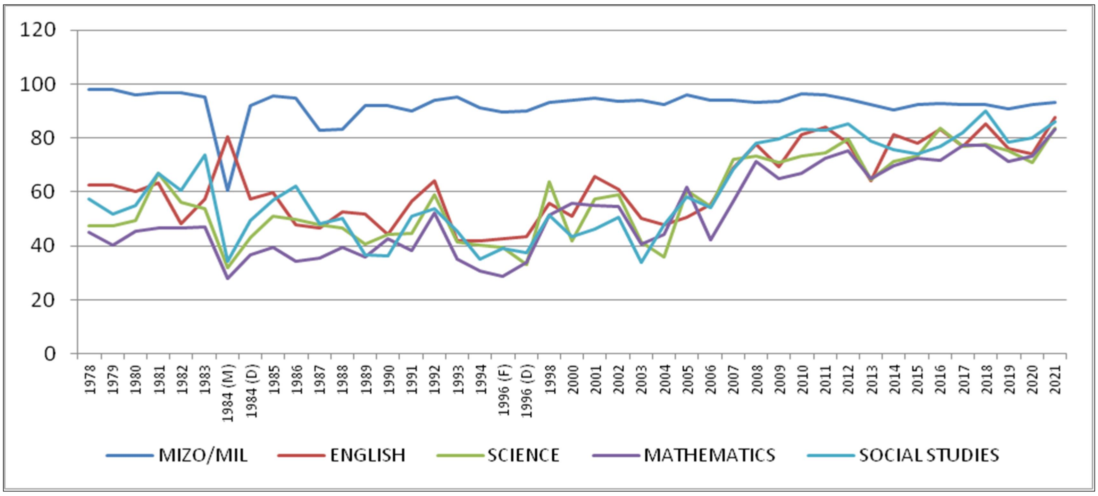


Figure 2.4: Subject-wise pass percentage of HSLC candidates under MBSE from 1978-2021

2.2 Method of Analysis:

In this study, regression analysis was used to find the factors responsible for the increase in Mathematics mark. Pearson correlation was also used to explore the degree of relationship between Mathematics and other factors and time series analysis was also engaged to compare the actual values and predicted values and to forecast for some years. Statistician George Box and Gwilym Jenkins developed a practical approach to build Auto-Regressive Integrated Moving Average (ARIMA) model, which best fit to a given time series and also satisfy the parsimony principle. Their concept has fundamental importance on the area of time series analysis and forecasting. The Box-Jenkins method does not assume any particular pattern in the historical data of the series to be forecasted. Rather, it uses a three step iterative approach of model identification, parameter estimation and diagnostic checking to determine the best parsimonious model from a general class of ARIMA model (Jordan Kern, 2017). This three step process is repeated several times until a satisfactory model is finally selected. Then this method can be used for forecasting future values of the time series (Box, Jenkins and Reinsel, 2003).

2.3 Linear Models and Regression Analysis:

Linear models play a central part in modern statistical methods. On the one hand, these models can approximate a large amount of metric data structures in their entire range of definition or at least piecewise.

Suppose the outcome of any process is denoted by a random variable y, called as dependent (or study) variable, depends on k independent (or explanatory) variables denoted by $X_1, X_2, \ldots, X_k$ Suppose the behaviour of y can be explained by a relationship given by

$$y = f(X_1, X_2, \ldots, X_k, \beta_1, \beta_2, \ldots, \beta_k) + \varepsilon$$

where f is some well-defined function and $\beta_1, \beta_2, \ldots, \beta_k$ are the parameters which characterize the role and contribution of $X_1, X_2, \ldots, X_k$ respectively. The term ε reflects the stochastic nature of the relationship between y and $X_1, X_2, \ldots, X_k$ indicates that such a relationship is not exact in nature. When $\varepsilon = 0$, then the relationship is called the mathematical model otherwise the statistical model. The term "**model**" is broadly used to represent any phenomenon in a mathematical framework.

A model or relationship is termed as linear if it is linear in parameters and nonlinear if it is not linear in parameters. In other words, if all the partial derivatives of y with respect to each of the parameters β_1, β_2,... β_k, are independent of the parameters, then the model is called a **linear model**. If any of the partial derivatives of y with respect to any of the β_1, β_2,..., β_k is not independent of the parameters, then the model is called as nonlinear. Note that the linearity or non-linearity of the model is not described by the linearity or nonlinearity of explanatory variables in the model (Gupta and Kapoor, 2013).

2.4 The simple linear regression model:

It is considered that the modelling between the dependent and one independent variable. When there is only one independent variable in the linear regression model, the model is generally termed as a simple linear regression model. When there is more than one independent variable in the model, then the linear model is termed as the multiple linear regression models.

2.5 The linear model:

Consider a simple linear regression model

$$y = \beta_0 + \beta_1 X + \varepsilon$$

Where y is termed as the dependent or study variable and X is termed as the independent or explanatory variable. The terms β_0 and β_1 are the parameters of the model. The parameter β_0 is termed as an intercept term, and the parameter β_1 is termed as the slope parameter. These parameters are usually called as **regression coefficients**. The unobservable error component ε accounts for the failure of data to lie on the straight line and represents the difference between the true and observed realization of y. There can be several reasons for such difference, e.g., the effect of all deleted variables in the model, variables may be qualitative, inherent randomness in the observations etc. It is assumed that ε is observed as independent and identically distributed random variable with mean zero and constant variance σ^2. Later, it will be additionally assumed that ε is normally distributed.

2.6 Multiple Linear Regression Model:

It is considered that the problem of regression when the study variable depends on more than one explanatory or independent variables, called a multiple linear regression model. This model generalizes the simple linear regression in two ways. It allows the mean function $E(y)$ to depend on more than one explanatory variable and to have shapes other than straight lines, although it does not allow for arbitrary shapes.

Let y denotes the dependent (or study) variable that is linearly related to k independent (or explanatory) variables $X_1, X_2,\ldots, X_k$ through the parameters $\beta_1, \beta_2,\ldots, \beta_k$ and then it is written as

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon$$

This is called the multiple linear regression models. The parameters $\beta_0, \beta_1, \beta_2,\ldots, \beta_k$ are the intercept and the regression coefficients associated with $X_1, X_2,\ldots,X_k$ respectively and ε is the random error component reflecting the difference between the observed and fitted linear relationship.

In this problem, the dependent variable (y) is the score in Mathematics subject and other covariates are

X_1 = Score in Science subject

X_2 = Score in Social science

X_3 = Score in English

X_4 = Score in Mizo

X_5 = Gender (i.e. Male =1, Female =2)

X_6 = Years (i.e. 1978 – 2021)

Then, the linear model becomes

Mathematics score = β_0 + β_1* Score in Science subject + β_2* Score in Social science + β_3* Score in English + β_4* Score in Mizo + β_5* Gender + β_6* Years + ε

There can be various reasons for such difference, for example, the joint effect of those variables not included in the model, random factors which cannot be accounted for in the model etc.

2.7 Principle of ordinary least squares (OLS):

To estimate the parameters involved in the regression model, least square-estimates or ordinary least square estimates method is adopted. In this case, it is assumed that a set of *n* paired observations on (x_i, y_i) , $i = 1,2,\dots,n$ are available which satisfy the linear regression model $y = \beta_0 + \beta_1 X + \varepsilon$. So the model for each observation can be written as $y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$, ($i = 1,2,\dots,n$).

The direct regression approach minimizes the sum of squares

$$S(\beta_0, \beta_1) = \sum_{i=1}^{n} \varepsilon_i^2 = \sum_{i=1}^{n} (y_i - \beta_0 - \beta_1 x_i)^2 \text{ with respect to } \beta_0 \text{ and } \beta_1.$$

The partial derivatives of $S(\beta_0, \beta_1)$ with respect to β_0 is

$$\frac{\partial S(\beta_0,\beta_1)}{\partial \beta_0} = -2\sum_{i=1}^{n}(y_i - \beta_0 - \beta_1 x_i)$$

The partial derivatives of $S(\beta_0, \beta_1)$ with respect to β_1 is

$$\frac{\partial S(\beta_0,\beta_1)}{\partial \beta_1} = -2\sum_{i=1}^{n}(y_i - \beta_0 - \beta_1 x_i)\, x_i$$

The solutions of β_0 and β_1 are obtained by setting

$$\frac{\partial S(\beta_0,\beta_1)}{\partial \beta_0} = 0$$

$$\frac{\partial S(\beta_0,\beta_1)}{\partial \beta_1} = 0$$

The solutions of these two equations are called the **direct regression estimators**, or usually called as the **ordinary least squares (OLS)** estimators of β_0 and β_1.

This gives the ordinary least squares estimates b_0 of β_0 and b_1 of β_1 as

$$b_0 = \bar{y} - b_1\bar{x}$$

$$b_1 = \frac{S_{xy}}{S_{xx}}$$

Where

$$S_{xy} = \sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})$$

$$S_{xx} = \sum_{i}^{n}(x_i - \bar{x})^2 \ ,$$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \ ,$$

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$$

2.8 Pearson correlation:

The degree of relationship between Mathematics and Science, Social science, Mizo, English, Gender and years was explored by using Pearson correlation coefficient.

The formula is given below

$$\rho = \frac{\sum_{i=1}^{n}(x_i - \underline{x})(y_i - \underline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \underline{x})^2 \sum_{i=1}^{n}(y_i - \underline{y})^2}}$$

where ρ is the correlation coefficient

x_i = values of the x variables in a sample

$\underline{x}$ = mean of the values of the x-variable

y_i = values of the y-variable in a sample

$\underline{y}$ = mean of the values of the y-variable

2.9 Time Series Analysis:

Secondary education plays a vital role in each child's life. It is crucial for the development of a child's personality as well as his/her career. It is around this age that children are exposed to the outside world and begin to make their own decisions. As a result, proper secondary education is critical for all the children. Obtaining secondary education will result in better economic status, reduce infant mortality rate and decrease child labor. So, it is necessary to know the nature of rate of pass percentages of Male and Female candidates in HSLC examination as an indicator of completion of secondary stage of education. The objective of this study is to fit a time series model and forecast the pass percentages of both male and female candidates in HSLC Examination, using time series data from 1978-2021. It is observed that ARIMA (0,1,1) models are useful for forecasting pass percentages of both Male and female (Marilena, 2015). The findings of this study may be helpful for effective planning and program implementation through proper budget allocation to ensure sustained growth and development of secondary education in Mizoram.

Statistician George Box and Gwilym Jenkins developed a practical approach to build ARIMA model, which best fit to a given time series and also satisfy the parsimony principle. Their concept has fundamental importance on the area of time series analysis and forecasting (Sangarshanan, 2018). The Box-Jenkins method does not assume any particular pattern in the historical data of the series to be forecasted. Rather, it used a three step iterative approach of model identification, parameter estimation and diagnostic checking to determine the best parsimonious model from a general class of ARIMA model (Analytics University, 2016). This three steps process is repeated several times until a satisfactory model is finally selected. Then this method can be use for forecasting future values of the time series (Agarwal and Adhikari, 2013).

The most important thing in time series analysis is Stationary (Chen et.al. 2008, Bisgaard and Kulahci, 2011). A stationary time series has constant mean, constant variance and constant autocorrelation structure. So, to conduct ARIMA model, the first thing that should be done is stationary test.

To reveal that the raw data is stationary:-

1) Examining the plot of raw data. To be stationary, the plot of the series should show constant location and scale.
2) Performing ACF Plots

$$\rho_k = \frac{\Upsilon_k}{\Upsilon_0} = \frac{autocovariance\ at\ lag\ k}{variance\ of\ the\ time\ series}$$

3) Performing Dickey-Fuller (ADF) unit root test for the non-stationary time series (Gujarati and Sangeetha, 2007).

If the series is stationary, then the assumption of constant mean and homogeneity variance are met. But if the pattern presents a trend, the method of differencing advocated by Box-Jenkins can be used to remove the linear trend.

After differencing the data to make non-stationary to stationary, the next step is to identify the order of ARIMA(p,d,q), where p represents the amount of auto-regression, d indicates the level of systematic change over time (trend) and q represent the moving average part. The basic method for identification of the order of ARIMA(p,d,q) are Autocorrelation Function (ACF) and Partial-Autocorrelation Function (PACF) and the resulting correlograms. After identifying appropriate p and q, then the parameter included in the model are estimated.

The best fit for ARIMA model was estimated according to the performance of Akaike Information Criterion (AIC). The model with the lowest AIC value was chosen as the best model. AIC is the best and important criteria to select the best model (Jamal Fattah, et al., 2018).

$$AIC = -2\ln(L) + 2k = n \ln(\sigma_a^2) + 2k$$

Where σ_a^2 *is* the maximum likelihood estimate and k is the number of parameters estimated in the model.

Performing the MAE (Mean absolute error), Mean absolute percentage error (MAPE) and Root mean square error (RMSE) to decide the better model.

1) $MAE = \frac{1}{n}\sum_{i-1}^{n}|Yi - Yj|$

2) MAPE = $\frac{1}{n}\sum_{i-1}^{n}\left|\frac{Yi-Yj}{Yi}\right| * 100\%$

3) RMSE = $\sqrt{\frac{1}{n}\sum_{i-1}^{n}|Yi - Yj|^{2}}$

Where n represent the number of observation, Yi represent the actual values and Yj values represent the predicted value (Chakraborty, Choudhury, Geeta and Sarma, 2016).

2.10 Ljung-Box Test (LB Test):

LB test is a test for autocorrelation that can be used in tandem with our ACF and PACF plots. It tests on the residuals of our model to look for auto-correlation; ideally our residuals would be white noise.

$$\text{LB} = n(n+2)\sum_{i-1}^{n}\left(\frac{p_k^2}{n-k}\right) \sim \chi_m^2$$

If observed value of χ_m^2 is less than the expected value of χ_m^2, then there is no evidence of white noise between the lags.

2.11 Results and Discussions:

The mean score of the subjects for each are calculated by using simple arithmetic mean, which is given in Table 2.2.

Table 2.2: The mean score for each subject

Years	**Subjects**					
	Variables	**Mathematics**	**Science**	**Social Science**	**English**	**Modern Indian Language**
1978	Scores (±SD)	22.830 (±13.982)	22.553 (±13.245)	29.378 (±13.872)	50.040 (±22.719)	106.118 (±21.820)
1979	Scores (±SD)	20.784 (±12.850)	24.661 (±11.406)	27.155 (±14.204)	48.135 (±18.987)	109.397 (±16.766)
1980	Scores (±SD)	21.544 (11.259)	24.118 (11.928)	22.678 (11.881)	44.698 (19.581)	114.544 (16.553)

1981	Scores (±SD)	22.513 (±13.325)	33.111 (±13.432)	31.763 (±13.726)	67.204 (±29.894)	82.451 (±17.434)
1982	Scores (±SD)	24.778 (±13.832)	30.459 (±13.578)	29.957 (±14.493)	58.987 (±27.164)	81.956 (±19.219)
1983	Scores (±SD)	47.340 (±14.670)	52.335 (±26.383)	42.495 (±15.827)	54.324 (±22.987)	82.742 (±19.505)
1984 (March)	Scores (±SD)	28.506 (±22.721)	36.118 (±23.459)	49.433 (±26.332)	72.413 (±25.952)	56.230 (±25.255)
1984 (December)	Scores (±SD)	38.875 (±18.738)	45.131 (±21.219)	63.625 (±25.868)	53.527 (±23.200)	75.340 (±22.524)
1985	Scores (±SD)	39.934 (±20.492)	47.950 (±24.302)	64.715 (±26.510)	51.401 (±21.808)	78.597 (±21.836)
1986	Scores (±SD)	36.838 (±21.760)	47.275 (±20.330)	58.240 (±22.853)	46.956 (±19.978)	81.764 (±16.675)
1987	Scores (±SD)	36.688 (±23.779)	43.582 (±25.703)	57.131 (±31.844)	43.805 (±24.386)	70.232 (±32.744)
1988	Scores (±SD)	37.823 (±22.704)	43.158 (±25.106)	59.357 (±33.065)	45.444 (±25.230)	70.087 (±32.418)
1989	Scores (±SD)	37.559 (±24.020)	39.218 (±23.614)	49.790 (±29.951)	44.691 (±24.936)	64.478 (±28.878)
1990	Scores (±SD)	42.162 (±26.451)	43.958 (±22.874)	51.481 (±26.854)	43.453 (±21.514)	75.092 (±23.332)
1991	Scores (±SD)	36.111 (±22.980)	42.118 (±22.917)	61.254 (±28.971)	49.231 (±23.003)	68.315 (±24.668)
1992	Scores (±SD)	41.714 (±24.918)	46.628 (±25.308)	59.493 (±31.976)	51.356 (±25.357)	74.031 (±28.808)
1993	Scores (±SD)	41.214 (±29.816)	50.442 (±29.617)	55.530 (±32.818)	59.248 (±33.859)	105.004 (±26.267)
1994	Scores (±SD)	41.705 (±28.673)	56.770 (±27.710)	48.733 (±30.152)	59.282 (±29.113)	99.710 (±26.758)

1996	Scores (±SD)	45.262 (±28.856)	57.581 (±27.916)	55.570 (±32.097)	90.045 (±26.305)	59.701 (±28.687)
1996 (December)	Scores (±SD)	48.820 (±26.819)	52.677 (±23.270)	52.896 (±27.143)	58.344 (±26.168)	95.010 (±26.636)
1998	Scores (±SD)	48.820 (±26.819)	52.677 (±23.270)	52.896 (±27.143)	95.010 (±26.636)	58.344 (±26.168)
2000	Scores (±SD)	67.377 (±33.540)	56.716 (±25.741)	56.482 (±30.014)	63.735 (±28.109)	106.488 (±28.439)
2001	Scores (±SD)	65.214 (±33.269)	66.723 (±27.403)	56.536 (±31.175)	75.256 (±30.254)	108.195 (±29.026)
2002	Scores (±SD)	64.097 (±32.060)	68.234 (±26.733)	60.700 (±29.309)	72.100 (±29.713)	101.149 (±26.843)
2003	Scores (±SD)	27.749 (±18.462)	38.409 (±19.342)	24.264 (±16.491)	34.930 (±17.440)	51.374 (±10.860)
2004	Scores (±SD)	28.907 (±18.503)	33.933 (±14.758)	31.724 (±17.756)	31.912 (±17.095)	52.760 (±11.996)
2008	Scores (±SD)	37.475 (±17.910)	47.051 (±16.771)	42.995 (±19.741)	39.172 (±15.917)	51.064 (±15.509)
2009	Scores (±SD)	34.101 (±19.229)	47.650 (±17.595)	44.156 (±19.607)	35.927 (±17.221)	51.472 (±15.692)
2010	Scores (±SD)	31.542 (±17.553)	46.621 (±15.456)	45.593 (±18.385)	41.417 (±17.653)	57.896 (±15.455)
2011	Scores (±SD)	35.912 (±16.492)	47.429 (±16.534)	43.283 (±17.612)	44.077 (±18.316)	65.535 (±16.788)
2012	Scores (±SD)	38.738 (±18.272)	47.919 (±16.745)	47.761 (±19.766)	41.521 (±19.777)	61.727 (±18.044)
2013	Scores (±SD)	34.369 (±17.276)	43.262 (±16.869)	41.059 (±17.584)	33.475 (±17.219)	59.306 (±19.113)
2014	Scores (±SD)	34.706 (±17.563)	44.326 (±16.838)	42.003 (±20.033)	42.225 (±18.929)	48.741 (±17.907)

2015	Scores (±SD)	36.823 (±18.263)	46.550 (±17.841)	39.141 (±19.274)	41.271 (±19.302)	55.653 (±19.057)
2016	Scores (±SD)	34.738 (±17.498)	50.617 (±18.245)	40.990 (±19.552)	41.054 (±17.156)	54.336 (±18.127)
2017	Scores (±SD)	45.064 (±17.994)	49.508 (±17.185)	50.887 (±19.452)	46.271 (±19.216)	59.611 (±18.172)
2018	Scores (±SD)	43.449 (±17.549)	47.391 (±16.550)	54.032 (±18.000)	50.985 (±19.257)	57.839 (±17.366)
2019	Scores (±SD)	41.837 (±17.966)	49.100 (±18.075)	48.776 (±19.433)	46.899 (±19.443)	58.221 (±18.789)
2020	Scores (±SD)	41.740 (±15.963)	46.771 (±16.627)	48.587 (±17.921)	44.469 (±17.977)	57.137 (±17.359)
2021	Scores (±SD)	51.873 (±20.083)	55.029 (±18.403)	57.901 (±21.994)	55.194 (±19.714)	62.195 (±18.631)

The degrees of relationship between subjects are calculated by using Pearson correlation coefficient, which is given in Table 2.3. For Mathematics subject, it is observed that the correlation coefficient is highest with Science subject (i.e. 0.796), which is positive and also significant at 1% and 5% level of significant indicating that if the score of science subject increases the score of mathematics subject will also be increased among the students. The smallest correlation coefficient observed between Mathematics subject and Major Indian Language with value 0.526 indicating that among all the major subjects, which has least impact on scoring higher marks in Mathematics. For English subject, the highest correlation coefficient observe with science subject indicates that if English score increase, science score will also be increased. For social science, the highest correlation coefficient observed with science subject with value 0.792, indicates that increase in science score will result in increase in social science also. But, for English subject, the correlation coefficient is highest with MIL, indicating that two languages are highly correlated. Generally, if they score good mark in English, they have the chance to get good mark in other language subject also.

Table 2.3: Correlation coefficient between subjects

Subjects		Mathe matics	English	Science	Social science	Modern Indian Language
Mathematics	Correlation coefficient	1	.675**	.796**	.717**	.526**
	p-value		<0.0001	<0.0001	<0.0001	<0.0001
	N	408435	408435	408435	408435	408435
English	Correlation coefficient	.675**	1	.720**	.712**	.630**
	p-value	<0.0001		<0.0001	<0.0001	<0.0001
	N	408435	408435	408435	408435	408435
Science	Correlation coefficient	.796**	.720**	1	.792**	.534**
	p-value	<0.0001	<0.0001		<0.0001	<0.0001
	N	408435	408435	408435	408435	408435
Social science	Correlation coefficient	.717**	.712**	.792**	1	.506**
	p-value	<0.0001	<0.0001	<0.0001		<0.0001
	N	408435	408435	408435	408435	408435
Modern Indian Language	Correlation coefficient	.526**	.630**	.534**	.506**	1
	p-value	<0.0001	<0.0001	<0.0001	<0.0001	
	N	408435	408435	408435	408435	408435
**. Correlation is significant at the 0.01 level (2-tailed).						

Regression analysis is also used to find the relationship between Mathematics subject and other subjects, which is given in Table 2.4. The highest regression coefficient observed in science with 0.530, which means that if the score of science increase by one mark, mathematics score will be increased by 0.530 marks.

The other significant variables which are contributing for the increase of Mathematics score are years, social science subject, English and Mizo. But, gender is not a significant for the score in mathematics mark. The value of the coefficient of determination (R^2) is also obtained and it is 0.673 indicating that subjects of science, social science, English, mizo, gender and years account for 67.3% of the total variation in mathematics mark. This means 32.7% is not accounted by other subjects, gender and years. This may be due to some others unknown factors related to studies.

Table 2.4: Regression Analysis

Variables	β	SE	t	p-values	95% Confidence interval for β		R^2	R^2 Adjusted
					Lower	Upper		
(Constant/ Intercept)	-10.806	0.113	-95.395	<0.0001	-11.028	-10.584		
Science	0.530	0.002	289.935	<0.0001	.527	.534		
Social science	0.171	0.002	113.271	<0.0001	.168	.174	0.673	0.673
English	0.130	0.001	88.052	<0.0001	.127	.133		
Mizo	0.103	0.001	92.245	<0.0001	.101	.106		
Gender	-0.081	0.044	-1.836	<0.066	-.167	.005		
Years	0.183	0.002	74.186	<0.0001	.178	.188		

Table 2.5 shows the regression analysis by stepwise method. In the table, estimated coefficients (β) of covariates, standard error of β estimates (SE), test statistic values, p-values and 95% confidence interval are shown. In first step, the Science is entered in the model and selected as the most important covariate out of 6 variables. In the second step, in addition to Science, English is entered in the model. In the third step, social science added to the science and English. In the fourth step, mizo added to the science, English and social science and in the last step, science, English, social science, mizo and years are entered in the model and these five covariates comprise the best set of the covariates which can explain the score of mathematics.

Table 2.5: Regression Analysis using Step wise method

Model	Variables	β	SE	t	p-values	95% Confidence interval for β	
						Lower	Upper
1	**(Constant)**	-.471	.055	-8.573	.000	-.579	-.364
	Science	.862	.001	840.369	.000	.860	.865
2	**(Constant)**	-2.673	.055	-48.548	.000	-2.781	-2.565
	Science	.697	.001	486.525	.000	.694	.700
	English	.210	.001	160.297	.000	.207	.213
3	**(Constant)**	-3.082	.054	-56.624	.000	-3.188	-2.975
	Science	.590	.002	341.992	.000	.587	.594
	English	.161	.001	117.176	.000	.158	.163
	Social science	.164	.002	107.859	.000	.161	.167
4	**(Constant)**	-5.165	.062	-82.896	.000	-5.287	-5.043
	Science	.578	.002	334.465	.000	.574	.581
	English	.121	.001	82.010	.000	.119	.124
	Social science	.161	.002	106.734	.000	.158	.164
	Mizo	.068	.001	67.483	.000	.066	.070
5	**(Constant)**	-10.908	.099	-110.310	.000	-11.102	-10.714
	Science	.531	.002	290.210	.000	.527	.534
	English	.130	.001	88.070	.000	.127	.133
	Social science	.171	.002	113.522	.000	.168	.174
	Mizo	.103	.001	92.946	.000	.101	.105
	Years	.183	.002	74.464	.000	.178	.187

2.12 Model Identification and Reliability checking for time series analysis:

To identify the appropriate model to be used, firstly years and pass percentage are plotted for Female candidates (Figure 2.5) and Male candidates (Figure 2.6). From this plot, it can be conclude that the data is non-stationary in mean and variance. The non-stationary pattern can also be confirmed by using ACF plot (Figure 2.7), PACF plot (Figure 2.8) for female candidates and ACF plot (Figure 2.9), PACF plot (Figure 2.10) for male candidates.

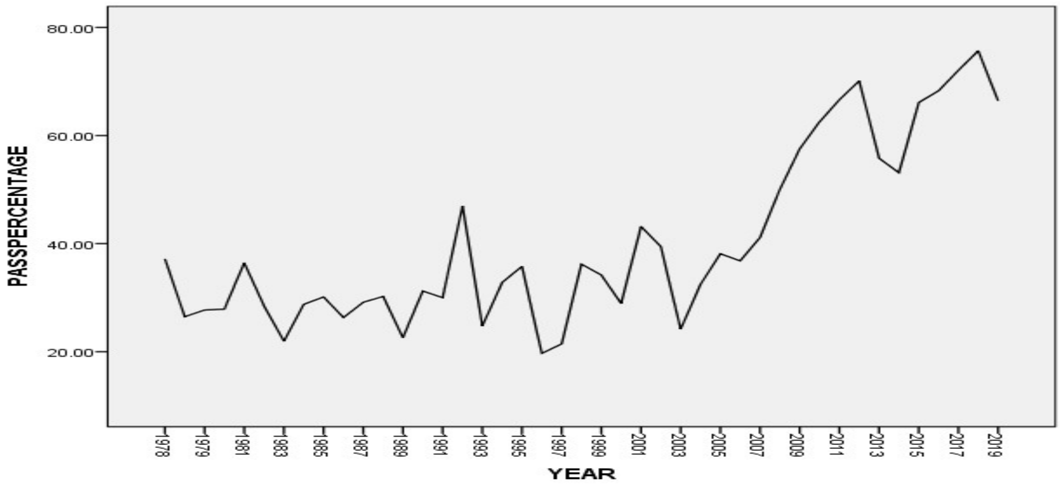


Figure 2.5: Plot of years against pass percentage for female candidates

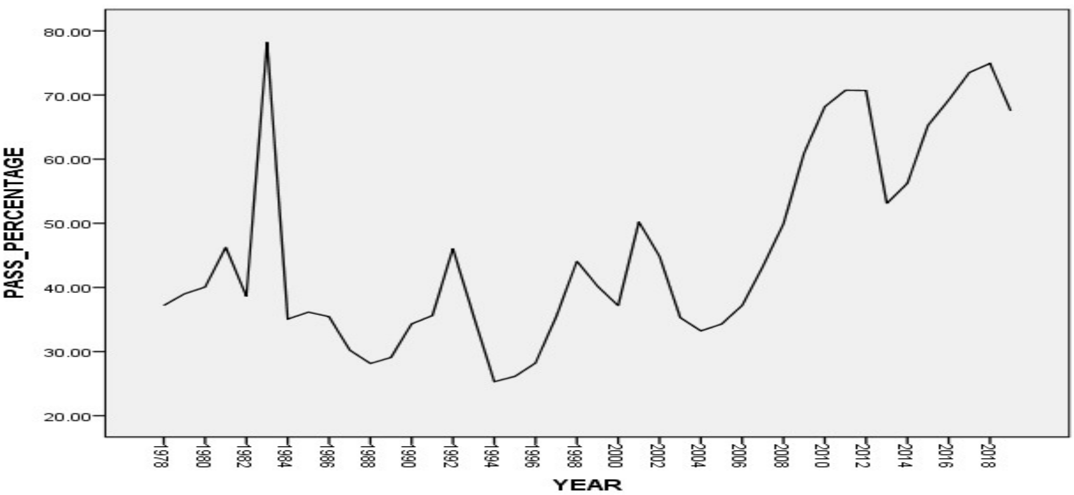


Figure 2.6: Plot of years against pass percentage for Male candidates

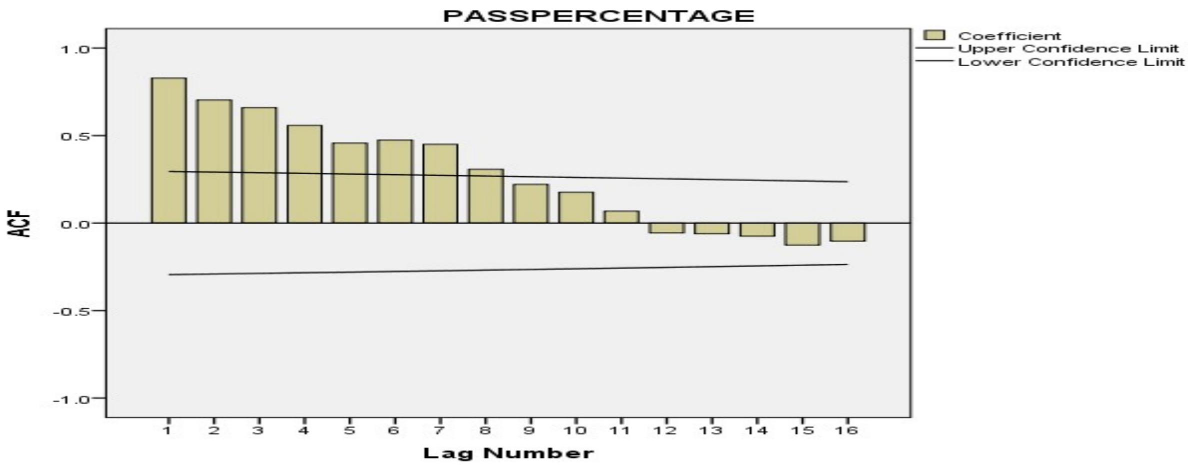


Figure 2.7: ACF Plot for Female candidates

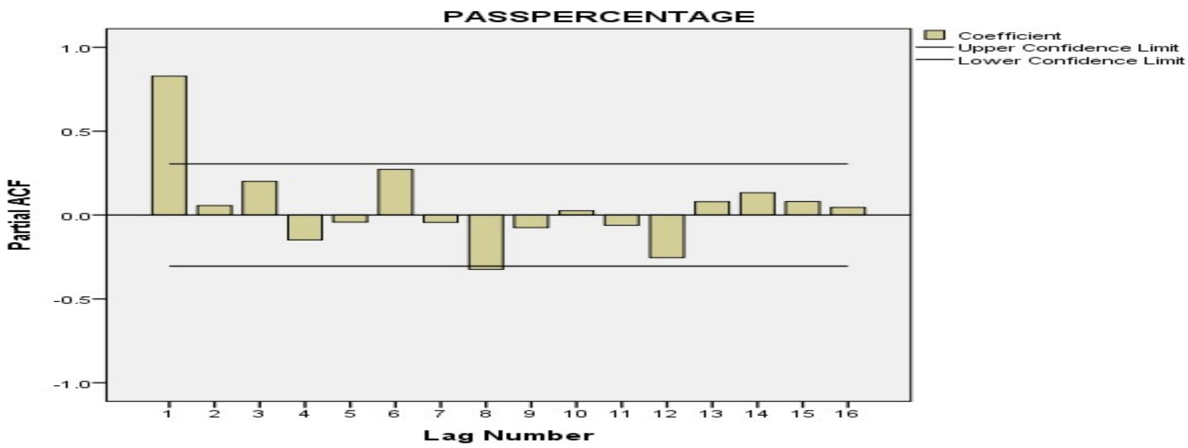


Figure 2.8: PACF Plot for Female candidates

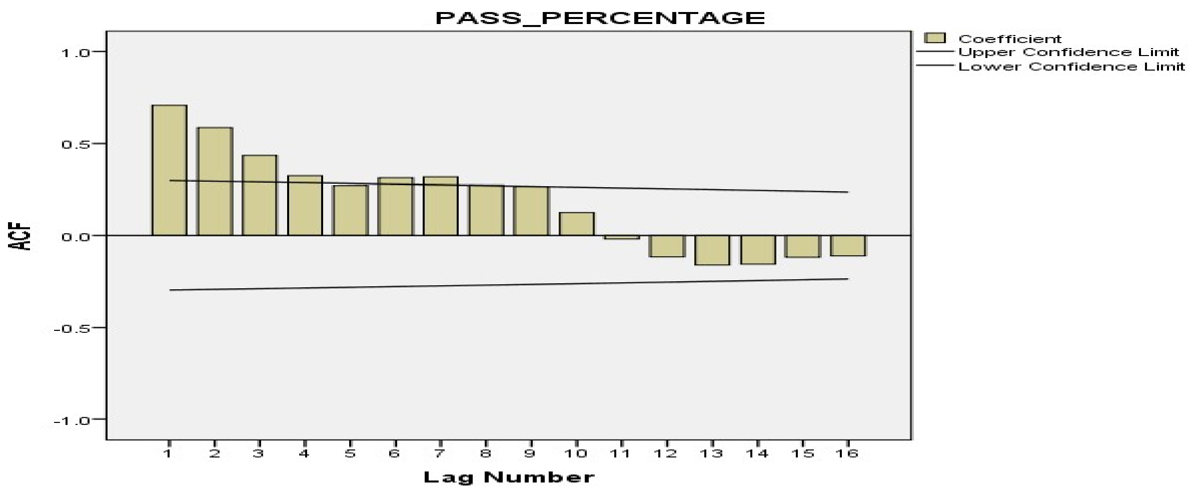


Figure 2.9: ACF Plot for Male candidates

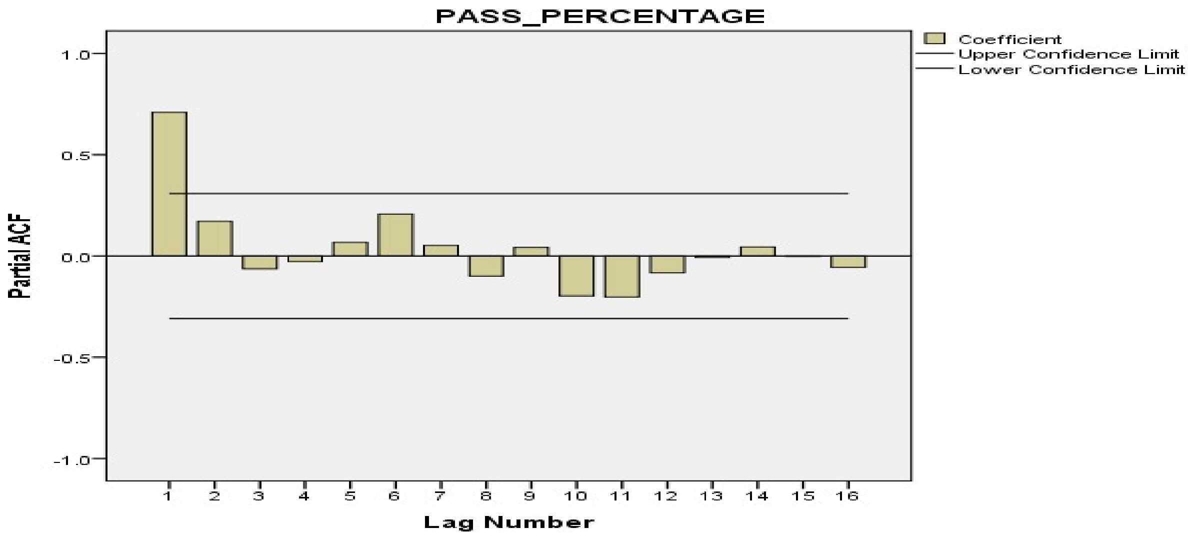


Figure 2.10: PACF Plot for Male candidates

From the above ACF Plots, it can be seen that the raw data does not die out even for large lags. Autocorrelation at lag 2 and above are merely due to the propagation of autocorrelation at lag 1. Therefore the time series is non-stationary. From the PACF plot, it can be conclude that the plot touch the significant value at lag 1 and lag 8, all the other does not touch the significant value. To confirm our time series is non-stationary, the Augmented Dickey-Fuller (ADF) unit root test is performed. With Dickey-Fuller = -2.0667 and p-value = 0.5473 for female candidates and Dickey-Fuller = -3.9804 and p-value = 0.02027, it can be conclude that the time series for the result of female and male candidates in HSLC Examination is non-stationary. To remove the non-stationary, differencing method is performed; the plots are given in Figure 2.8 and Figure 2.9.

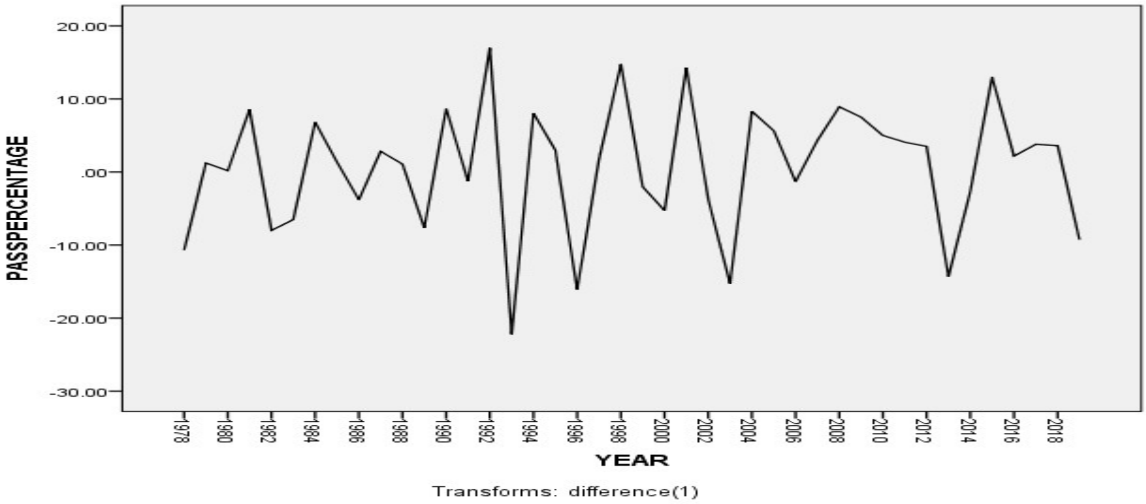


Figure 2.11: Plot of Years against Pass percentage after differencing for female candidates.

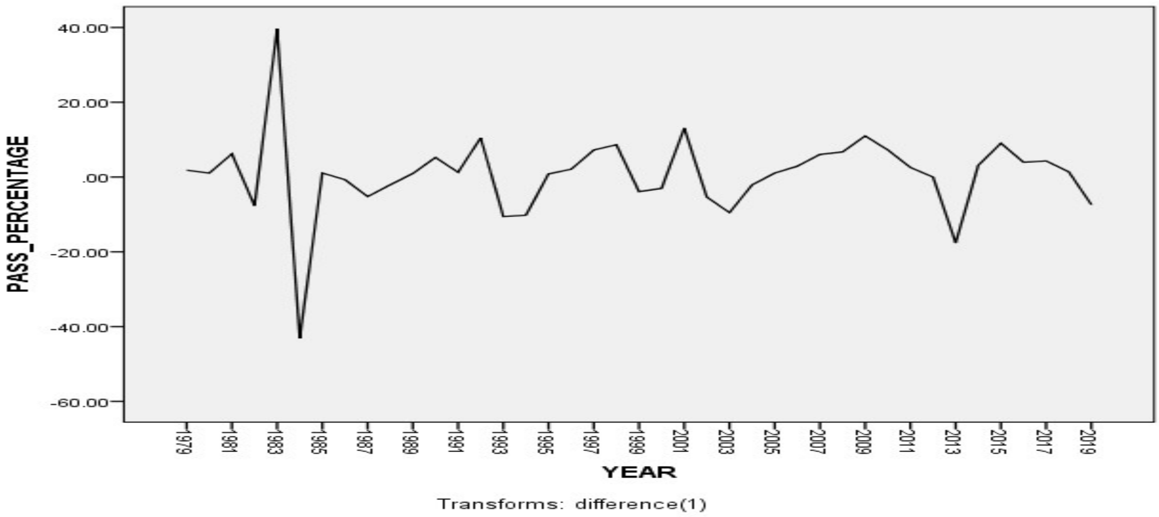


Figure 2.12: Plot of Years against Pass percentage after differencing for male candidates.

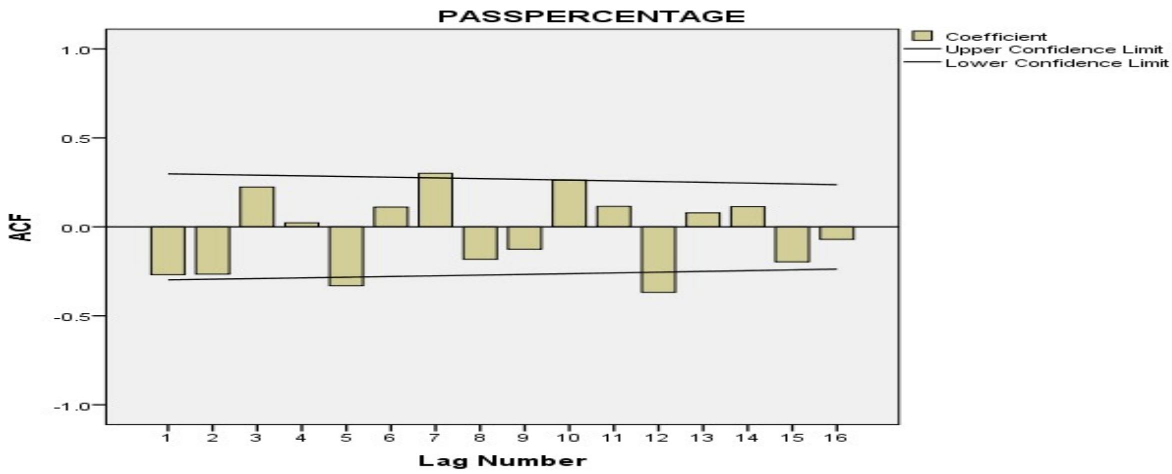


Figure 2.13: ACF Plot after differencing for female candidates

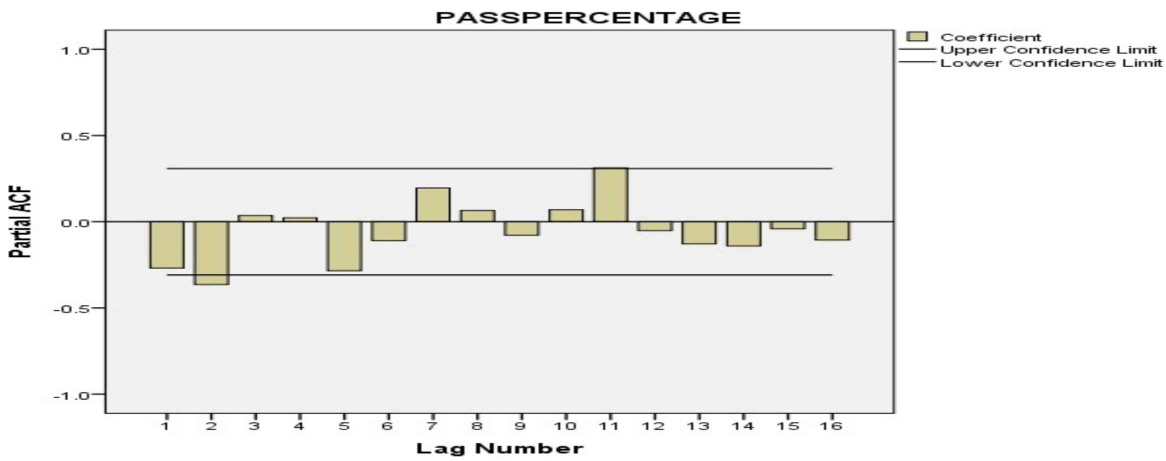


Figure 2.14: PACF Plot after differencing for female candidates

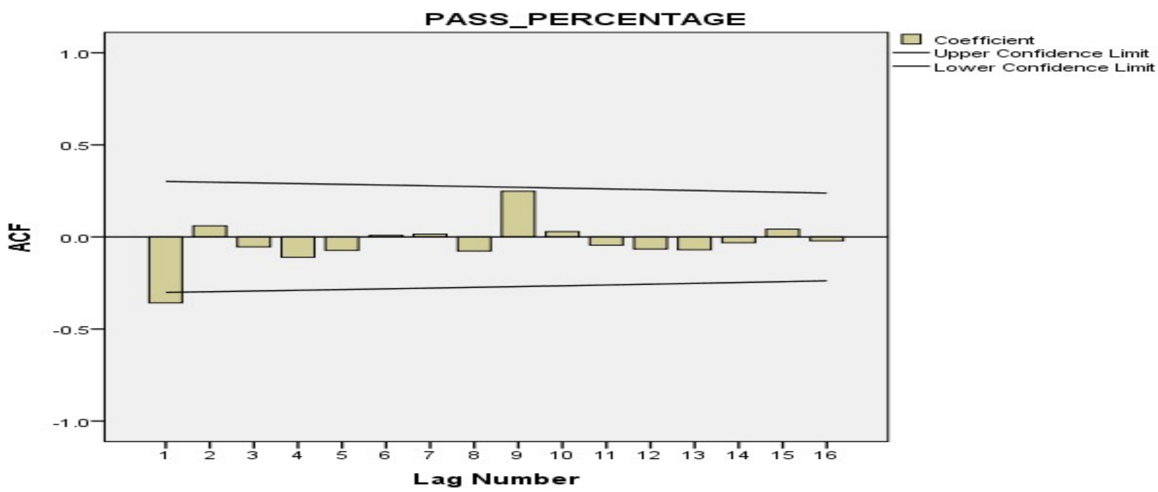


Figure 2.15: ACF Plot after differencing for male candidates

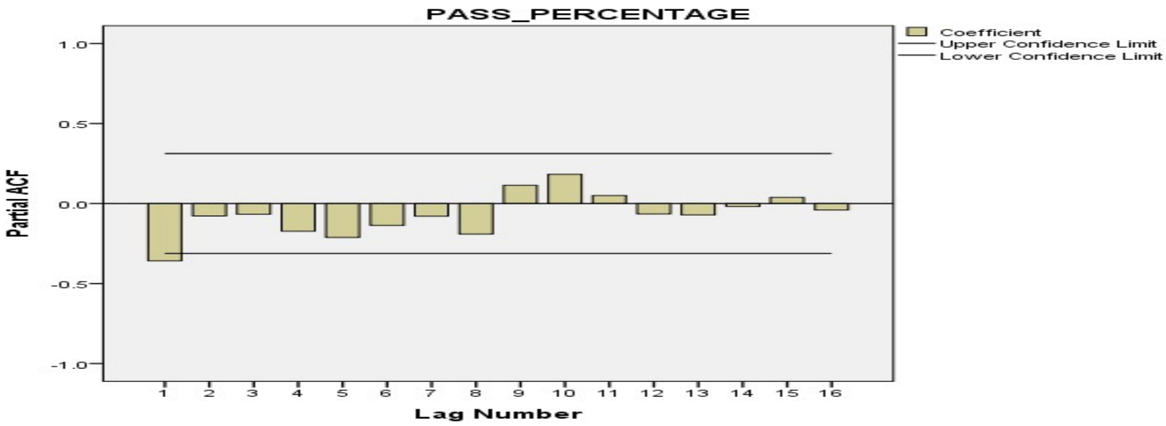


Figure 2.16: PACF Plot after differencing for male candidates

Figure 2.11 and Figure 2.12 represent the first differenced time series plot and Figure 2.13 and Figure 2.14 represent the ACF and PACF plot of first differenced series for female candidates and Figures 2.15 and 2.16 represent the ACF and PACF plot of first differenced series for male candidates. With Dickey-Fuller = -3.5073 and p-value = 0.04586 for female candidate and Dickey-Fuller = -3.9804 and p-value = 0.02027 for male candidates, it is concluded that the time series is now stationary.

For identifying the ARIMA (p,d,q) model, Figures 2.13 and 2.14 are examined for female candidates and Figures 2.15 and 2.16 for male candidates. The most appropriate model may be ARIMA (0,1,1) for female candidates and for male ARIMA (0,1,1) is the most appropriate model. So, all the analysis will be based on this model for the female and male candidates.

Now performing the Diagnostic check for further check on how well the ARIMA (0,1,1) Model fit the data. Figures 2.17 and 2.18 represents the ACF and PACF of residuals after fitting the ARIMA (0,1,1) model for female and male candidates. From this plots, it can be seen that none of these plots does not touch the significant bound and hence concluded that the nature of residuals in Figures 2.17 and 2.18 indicates that the ARIMA (0,1,1) model fits well the data of female candidates and male candidates.

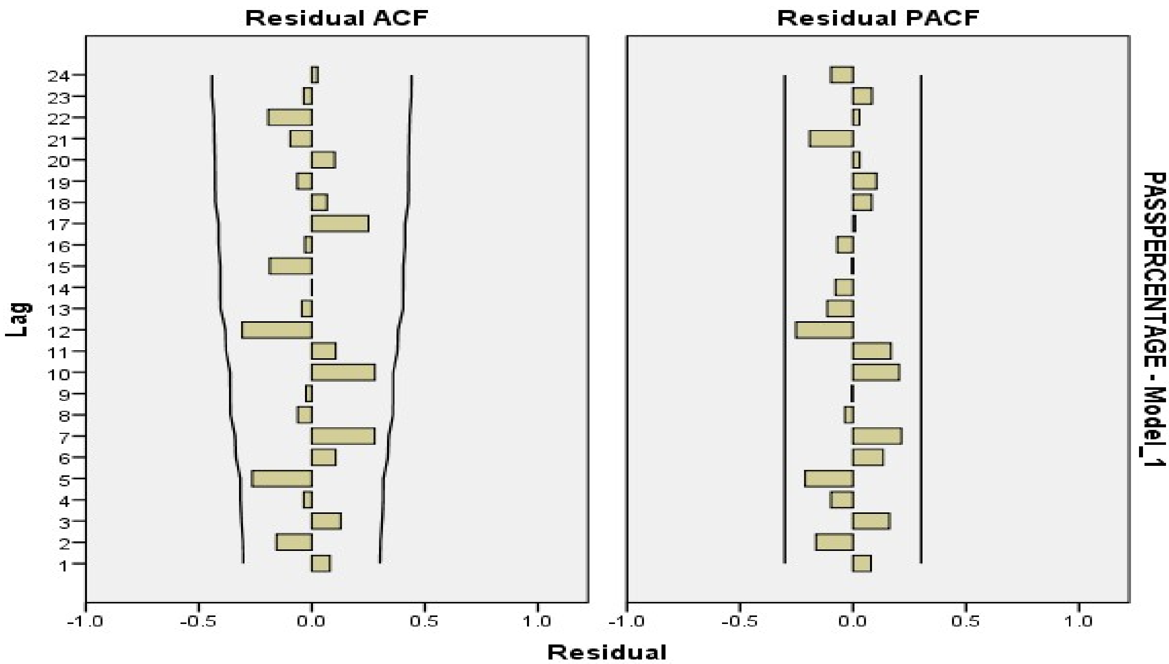


Figure 2.17: ACF and PACF Plot of residual for female candidates

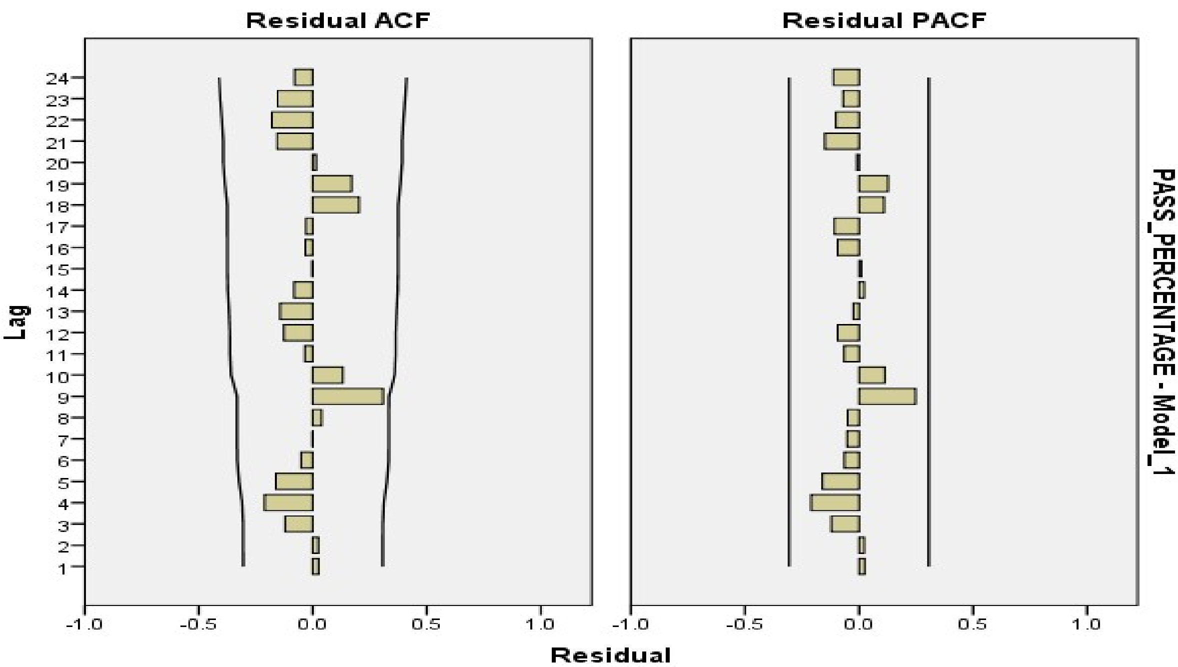


Figure 2.18: ACF and PACF Plot of residual for male candidates

2.13. Comparison of Actual and Forecast pass percentage values:

By using ARIMA (0,1,1) model, the pass percentage of the female and male candidates are forecasted for the years 2020 and 2021 and compared with the actual pass percentage. It is observed that the pass percentage and forecast value is not much different in 2020 for both male and female but the value of pass percentage and actual values are much different in the year 2021 because of substantial increase in pass percentage for the year 2021, this may be the result of reduction of course content by about 30% from full syllabus due to Covid-19 pandemic. If there is no other factor related to examination, time series analysis is reliable to forecast for the next years to come. The actual values and forecast values with 95% confidence intervals for male and female are given in Table 2.6.

Table 2.6: Forecast value with 95% Confidence Interval.

Gender	Year	Actual Value	Forecast value	95% Confidence Interval	
				Lower	Upper
Female	2020	69.23	71.49	55.90	87.07
	2021	80.03	72.56	55.35	89.77
Male	2020	67.83	69.82	49.17	90.47
	2021	83.51	70.56	45.85	93.79

2.14 Time series analysis of HSLC marks and Forecasting:

Figure 2.19 and Figure 2.20 represents the time series plot of pass percentages of male and female candidates in HSLC examination in Mizoram for all the years 1978 to 2021. From this plot, it can be observed that rapid increasing pattern in the period of 1982-1983 and rapid decline in the period of 1983-1984,then slowly decreasing from 1984-1988 and start increasing up to 1992 and again decreasing. So, it can be concluded that the data is non-stationary in mean and variance.

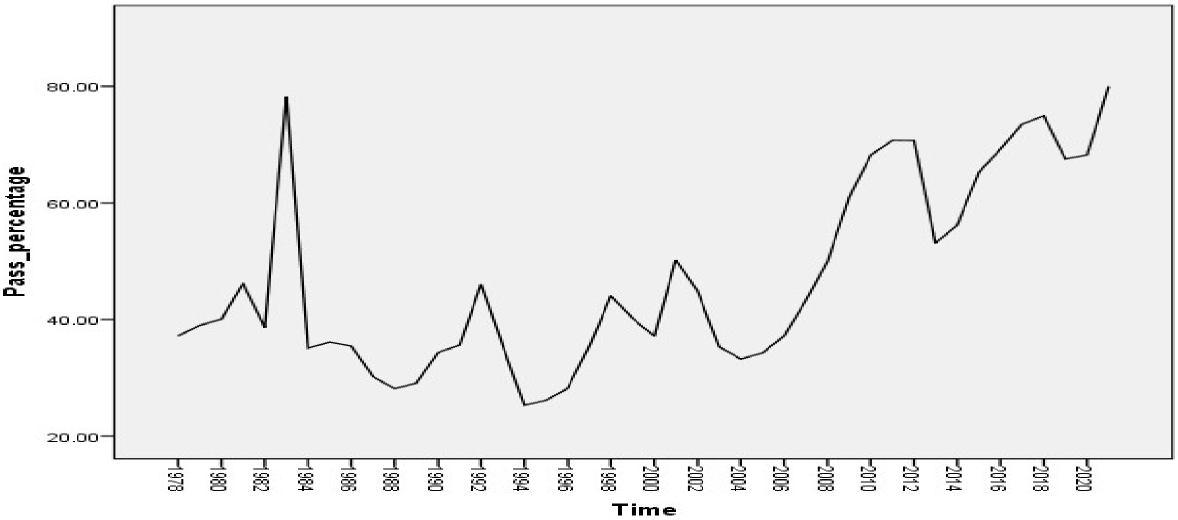


Figure 2.19: Time Series plot of male pass percentage against years

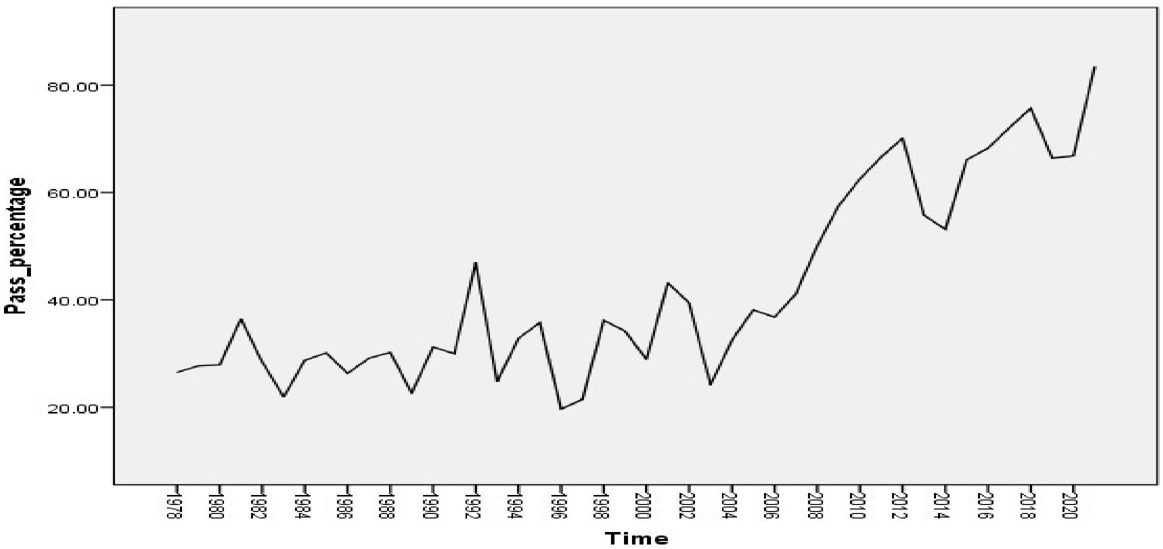


Figure 2.20: Time Series plot of female pass percentage against years

The non-stationary pattern was also confirmed by looking the ACF plots (Figure 2.21 and Figure 2.22) for male and female candidates and PACF plots (Figure 2.23 and Figure 2.24) for male and female candidates. From ACF Plot, the raw data does not die out even for large lags. Autocorrelation at lag 2 and above are merely due to the propagation of autocorrelation at lag 1. Therefore, the time series is non-stationary (Bisgaard and Kulahci 2011, Gujarati and Sangeetha 2007). From

PACF plots, it can be concluded that the plot though the significant value only in lag 1 and all the higher order autocorrelation are effectively explained by lag 1 autocorrelation. Now the Augmented Dickey-Fuller (ADF) unit root test is performed to confirm our time series is non-stationary. With Dickey-Fuller = -2.2172 and p-value = 0.4878, then it can be concluded that the time series for result of appeared male candidates in HSLC Examination is non-stationary. To remove the non-stationary, differencing method is performed.

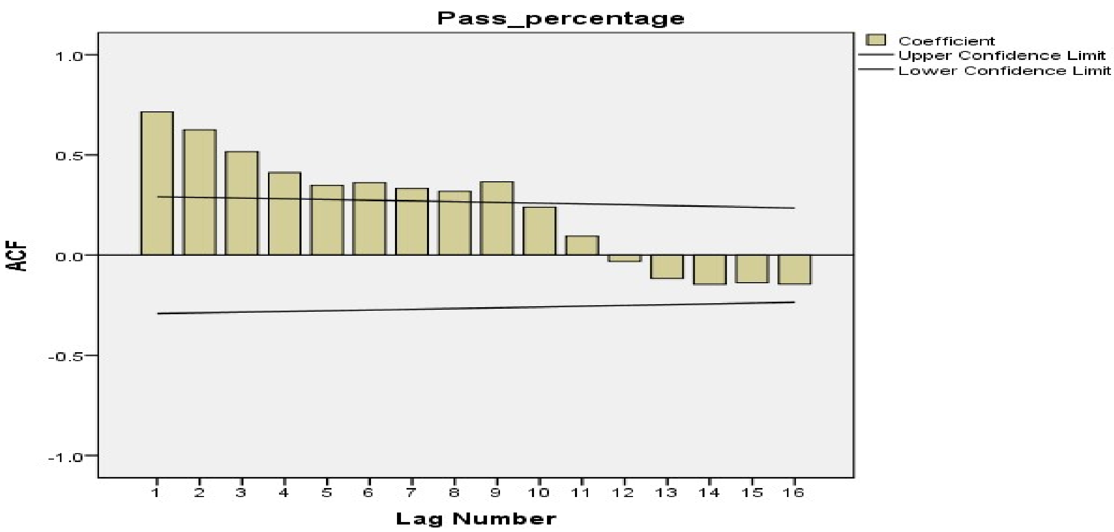


Figure 2.21: ACF plot for male candidates

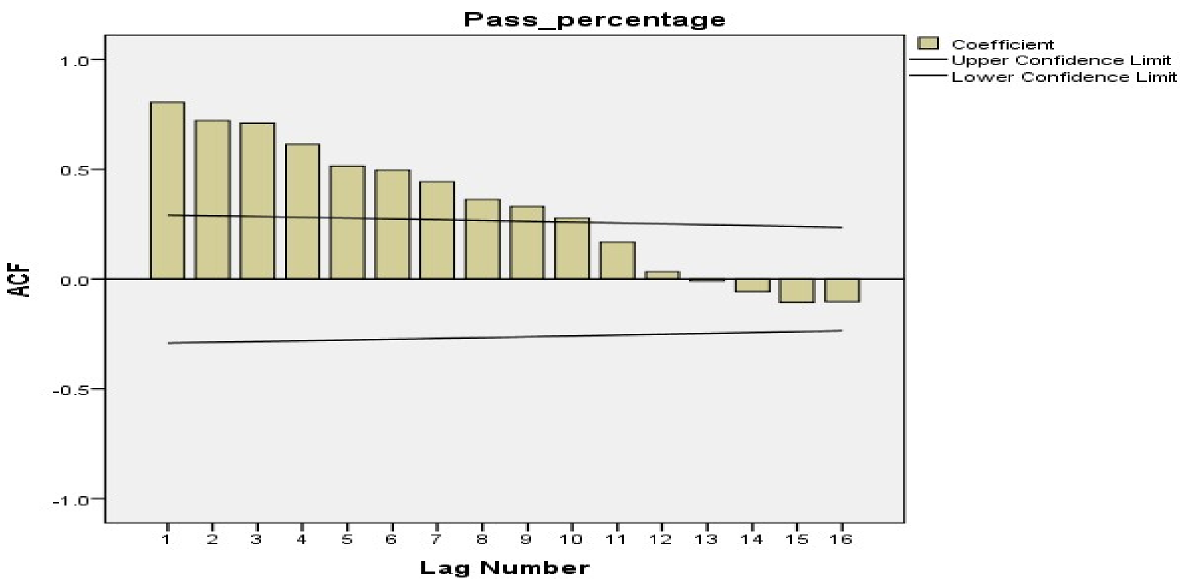


Figure 2.22: ACF plot for female candidates

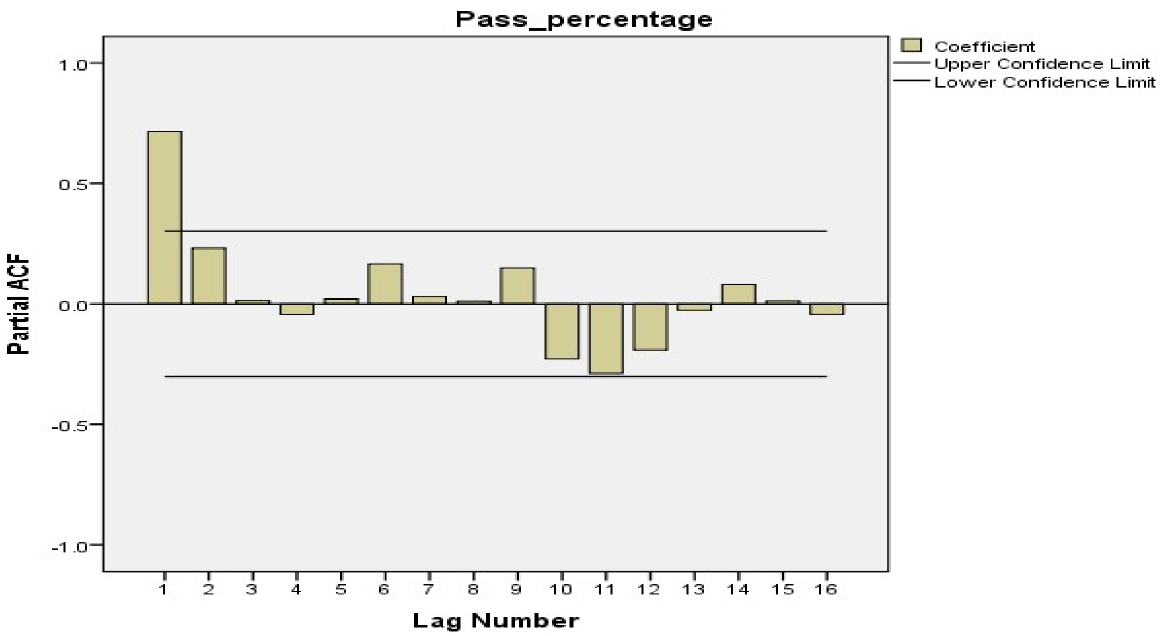


Figure 2.23: PACF Plot for male candidates

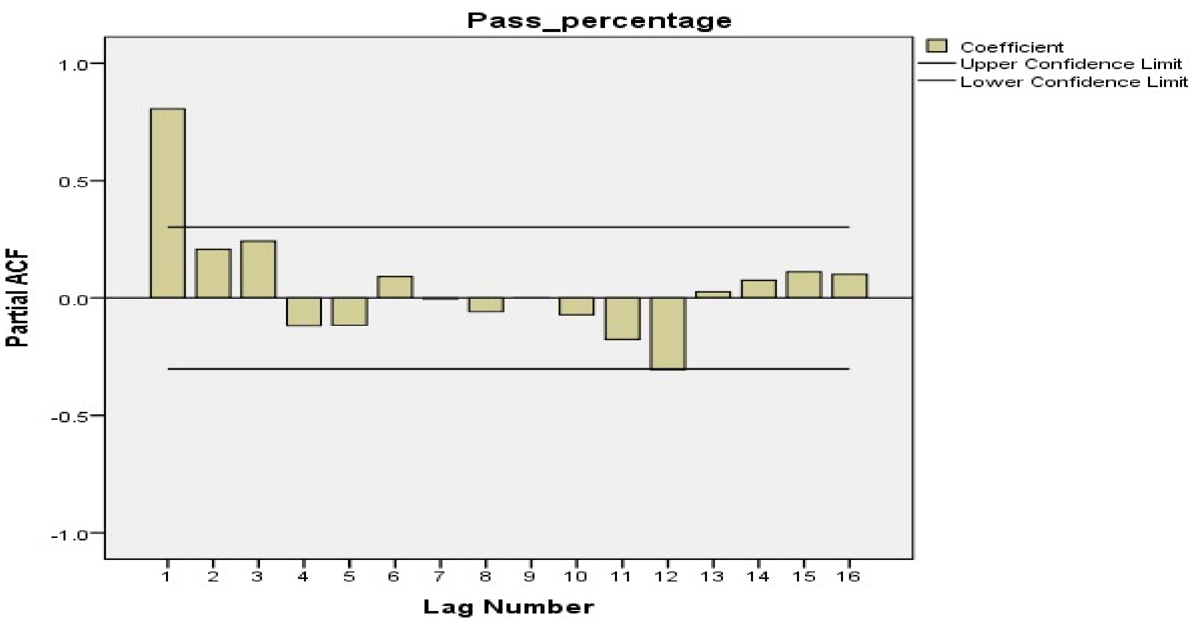


Figure 2.24: PACF Plot for female candidates

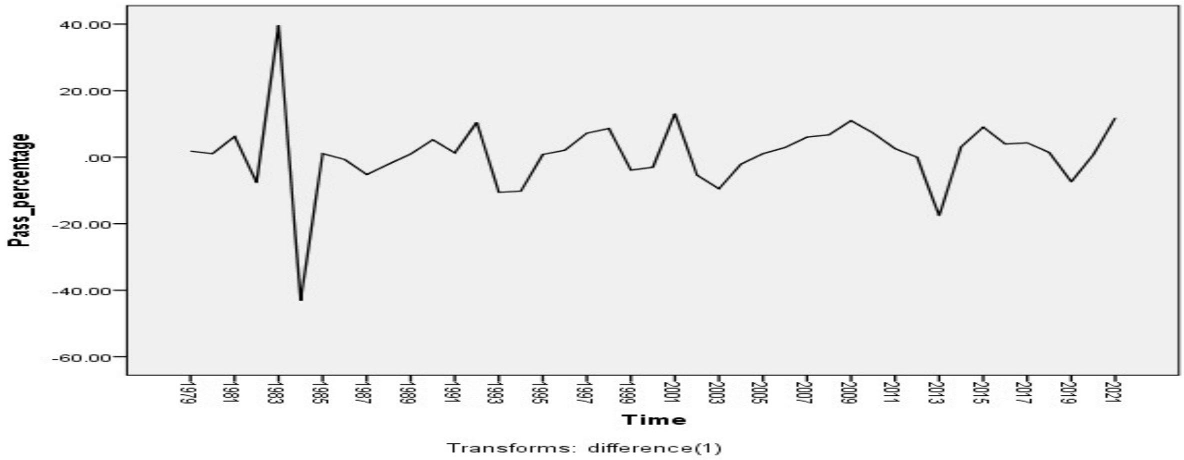


Figure 2.25: Time series plot of pass percentage against years after differencing for male candidates.

Figure 2.26: Time series plot of pass percentage against years after differencing for female candidates.

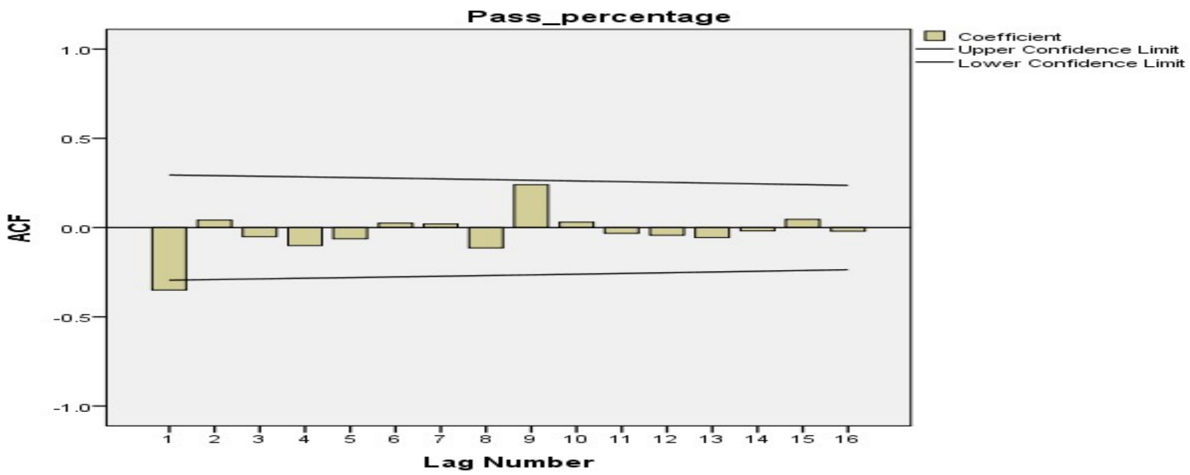


Figure 2.27: ACF Plot after first differenced for male candidates

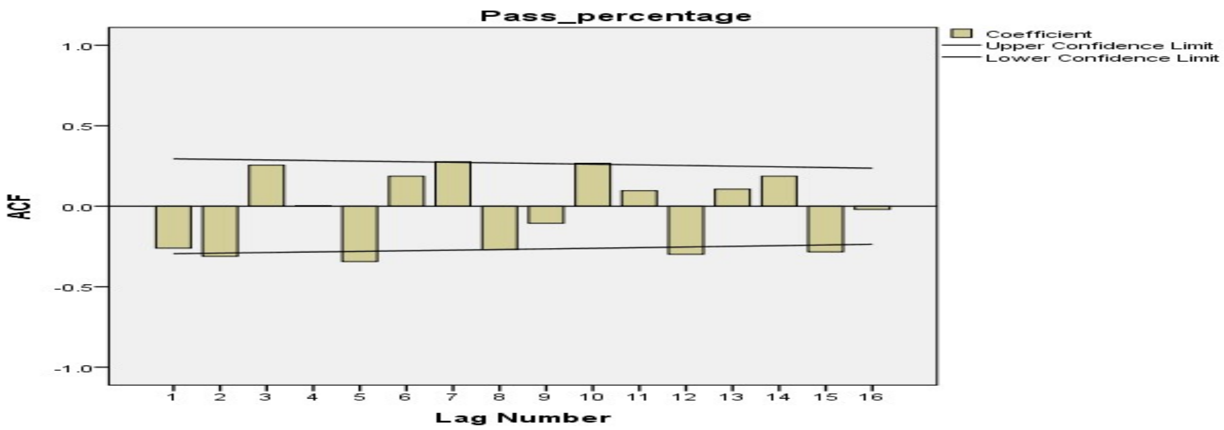


Figure 2.28: ACF Plot after first differenced for female candidates

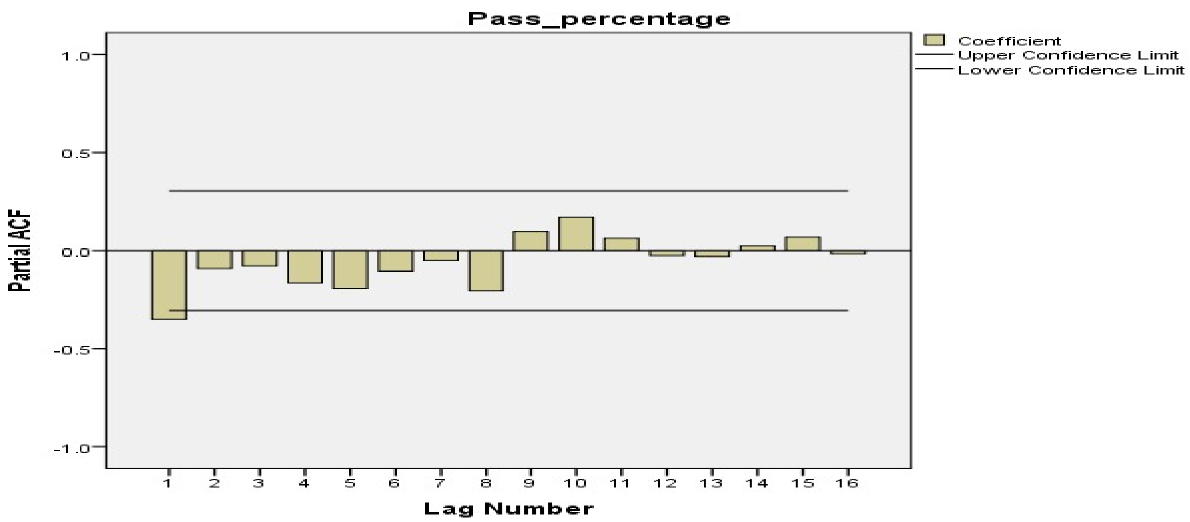


Figure 2.29: PACF Plot after first differenced for male candidates

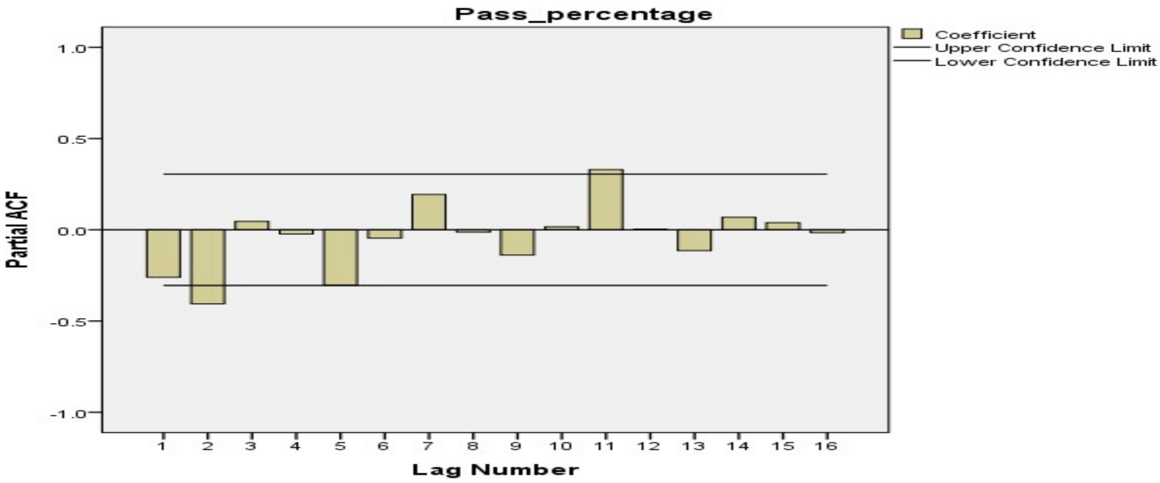


Figure 2.30: PACF Plot after first differenced for female candidates

From the ACF and PACF plots for male and female candidates, it can be concluded that at ACF and PACF down quickly at lag 2 and the entire higher lag were in inside the confidence interval, so the non-stationary is reduced and become a stationary time series. The Test is performed to confirm the stationary of the first differenced series. With Dickey-Fuller = -4.1656 and p-value = 0.01231 for male candidates and Dickey-Fuller = -3.7631 with p-value = 0.03171. So it is concluded that the series is now stationary.

2.15 Model Identification:

For identifying the ARIMA (p,d,q) model, Figures 2.27 and 2.29 are examined for male candidates and Figures 2.28 and 2.30 for female candidates. Here, the series are differenced only once, so d = 1. For p order, PACF Plots are examined in Figures 2.29 and 2.30. From the PACF Plots, it is observed that lag 1 touch the significant bound and all the other correlation drops near to zero. So, PACF Plot suggests that an AR (1) could be accurate in the present time series. For q order, ACF Plot is examined in Figures 2.27 and 2.28 for male and female candidates. From the ACF Plots, it is observed that lag 1 touch the significant bound and all the other correlation drops near to zero. So, ACF Plot suggests that an MA (1) could be accurate in the present time series. p,d,q have been identified . So our potential models for male and female candidates may be

For Male candidates

1) ARIMA (1,1,0)
2) ARIMA (1,1,1)
3) ARIMA (0,1,1)

For Female candidates

1) ARIMA (1,1,2)
2) ARIMA (1,1,1)
3) ARIMA (0,1,1)

After finding the possible parameters for the ARIMA model from ACF and PACF Plot, how many lag are significant are needed to be known and it is needed to test various models upto those lags to find out the best model. Akaike Information Criteria (AIC) is a criterion for a selection of best fit model. The model with the lowest AIC is the best model. So, the model is selected with the lowest value of AIC, MAPE, RMSE and MAE. So, from the table 1, it is concluded that ARIMA(0,1,1) is the best model for stationary time series.

Table 2.7: The AIC, MAPE and MAE values for the time series of participated male candidates (1978-2021)

Gender	**Model**	**AIC**	**RMSE**	**MAE**	**MAPE**	**R^2**
Male	ARIMA(1,1,0)	328.92	10.57	7.41	87.15	0.125
	ARIMA(1,1,1)	328.33	10.44	7.38	83.45	0.167
	ARIMA(0,1,1)	326.81	10.43	7.63	78.75	0.148
Female	ARIMA(1,1,2)	307.01	8.53	6.42	85.66	0.023
	ARIMA(1,1,1)	306.92	7.99	6.07	75.37	0.113
	ARIMA(0,1,1)	305.67	8.04	6.226	84.738	0.175

2.16 Model parameters estimation:

After identifying the model, the parameters are estimated. The estimated parameters are given below in Table 2.8.

Table 2.8: Estimated Coefficients for an ARIMA (0,1,1) Model (Pass percentages for male and female)

Model	Coefficient	Standard error	Sigma-square	Log-likelhood	p-values
MA(1)	0.456	0.141	106.7	-161.41	0.002
MA(1)	0.555	0.134	64.74	-149.84	0.004

2.17 Diagnostic Checking:

Performing Diagnostic check to further check how well the ARIMA (0,1,1) model fit the data. From ACF and PACF plots of Residuals for male and female candidates (Figure 2.31 and Figure 2.32) and Ljung-Box Chi Square value (Table 2.9) after fitting the ARIMA(0,1,1) model , it can be seen that none of these plots does not tough the significant bound and hence it can be concluded that the nature of residuals in Figure 2.28 indicates that the ARIMA(0,1,1) model fits the data well.

Table 2.9: Ljung-Box Chi Square

Gender	χ^2 (Calculated)	χ^2 (Tabulated)	p-values
Male	14.76	27.59	0.05
Female	19.25	27.59	0.05

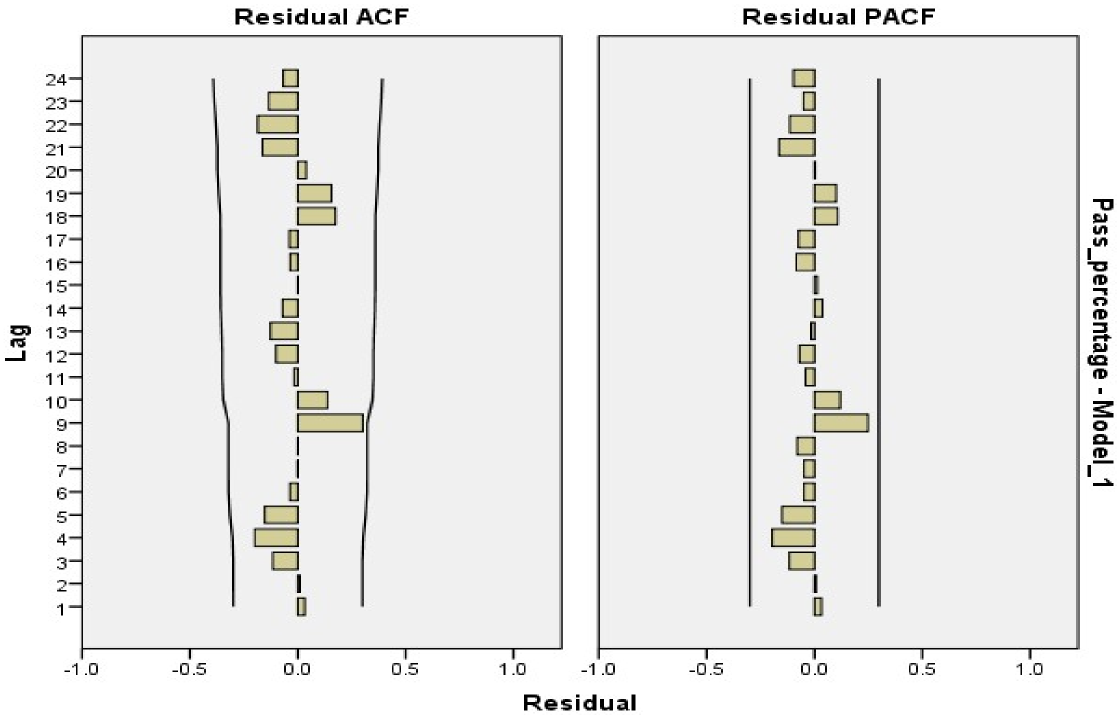


Figure 2.31: Residual ACF and PACF plots for male candidates

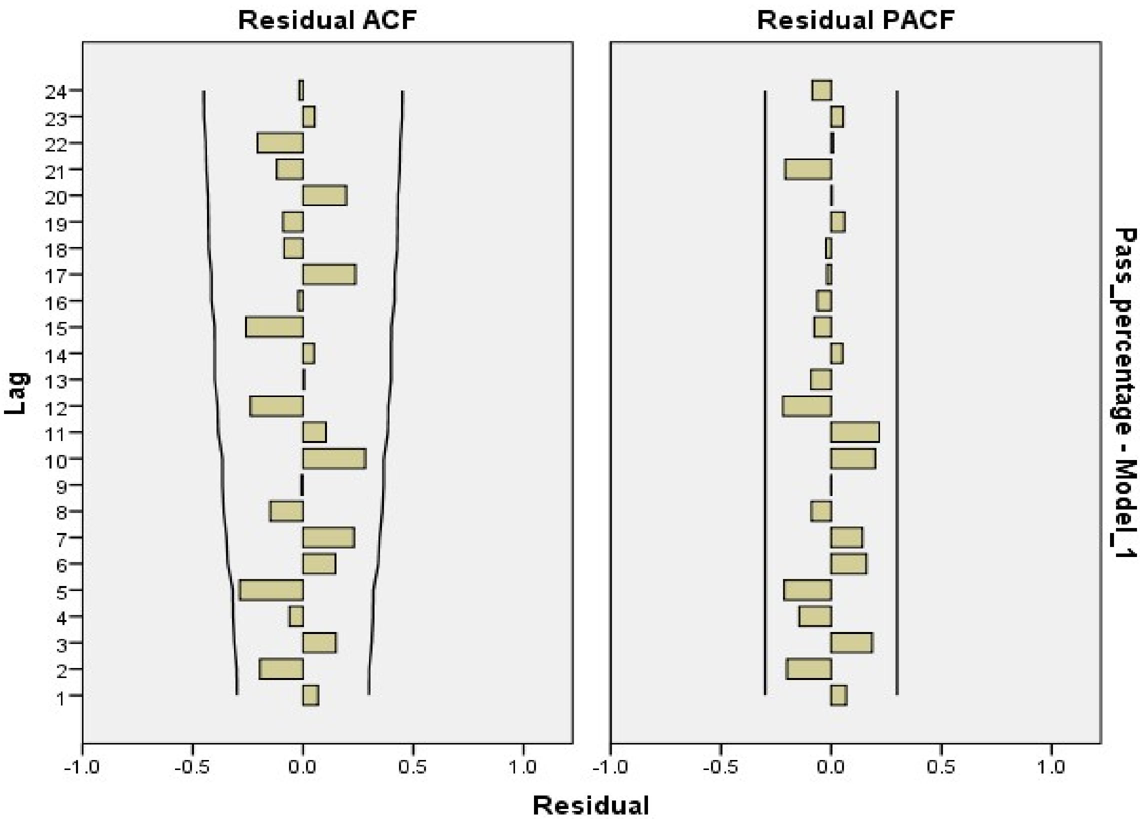


Figure 2.32: Residual ACF and PACF plots for female candidates

2.18 Forecasting:

The model ARIMA(0,1,1) is fitted to our time series. After the most appropriate model has been defined in our case, forecasting has to be made, to do this and so to predict trends and develop forecast, the IBM SPSS Forecasting is used. Table 2.10 presents the forecast values of the pass percentage of male and female candidates in HSLC by applying our model ARIMA(0,1,1) for the next 5 years.

Table 2.10: Forecast with 95% prediction intervals for the pass percentage of male candidates in HSLC after fitting ARIMA(0,1,1) Model from 1978-2021.

Gender	Year	Forecast (Pass percentage)	95% Confidence interval	
			Lower	Upper
Male	2022	73.33	54.95	95.82
	2023	75.38	51.73	99.04
	2024	75.38	48.90	101.87
	2025	75.38	46.35	104.42
	2026	75.38	44.01	106.77
Female	2022	77.57	61.80	93.34
	2023	78.74	61.48	96.00
	2024	79.90	61.27	98.53
	2025	81.07	61.16	100.97
	2026	82.23	61.13	103.33

2.19 Discussion:

A time series analysis of the results of appeared candidates in matriculation/HSLC Examination in Mizoram from 1987-2021 has been done by Box-Jenkins ARIMA model.

From the analysis, It is found that ARIMA (0,1,1) model is the best fit model for male and female candidates respectively in our study. Firstly our raw data are differenced to eliminate non-stationary (Dickey-Fuller = -2.2172,-2.0008 and p-value

= 0.4878, 0.5735 for male and female respectively) and confirmed stationary by performing ACF and PACF Plot of differenced data and also performed Dickey-Fuller test.

It is found that Dickey-Fuller = -4.1656, -3.7631 with p-value = 0.01231, 0.03171 for male and female respectively, therefore the null hypothesis of non-stationary is rejected and then it can be concluded that the time series data is stationary. Then the parameter is estimated and after that Diagnostic test is performed followed by residual analysis. Then the pass percentage of both male and female candidates in HSLC Examination for the next Five years namely 2022, 2023, 2024, 2025 and 2026 is forecasted respectively along with their 95% prediction interval.

The corresponding forecasted pass percentage for male is 73.33 with 95% lower and upper prediction limits 54.95 and 95.82 respectively and pass percentage for female is 77.57 with 95% lower and upper prediction limits 61.80 and 93.34 respectively.

It is also observed that female candidates will have higher pass percentage as compared to male candidates in the next five years; it will be very challenging for male candidates.

In a time series generated by stochastic process, it is not always possible to exactly predict the output of the process in the future (Bisgaard and Kulahci 2011).

CHAPTER 3

ASSESSMENT OF THE AVAILABILITY AND BARRIERS OF ICT FOR TEACHING AND LEARNING IN SCHOOLS OF MIZORAM

3.0 Introduction

Various studies have found that the application of new technologies in teaching and learning of students in the classroom is needed for the development of education. It is clear that traditional method of education is not suitable for today's learners and to function to be productive in the workplaces of modern society. The use of new technologies can assist students to become knowledgeable, faster, better and also give teachers an opportunity to help those students with their special needs. Even in the pandemic world, education can run with the help of ICT without a break.

Different researches conducted on ICT availability in education have improves the quality of learning and performance of learners. Moreover, ICT availability simplifies abstract and complex concepts, creates cooperative learning and interest in learning among students. Having more teachers who can integrate their teaching with ICT resources is needed. If some teachers could not apply ICT in their teaching job, their work could not fully and effectively function in this challenging world (Kellenberger & Hendricks, 2000). Learners are going to suffer when they enter the places of ICT application. Thus, Government, Parents and Teachers need to have improvements on ICT programs so that there can be better future for the education of students.

Recent studies found out that lack of time is an important factor affecting the application of ICT in modern education. Some teachers think that the use of ICT has no benefits or unclear benefits for their teachings. Low numbers of computers, oldness or slowness of ICT systems and scarcity of educational software in the schools are major barriers for the successful implementation of modern education. Therefore, the Government and the Institutions need to give much effort for the alleviation of these problems. If these problems can be solved, there can be advancement for the teachers and students in the coming generations.

Presently, there are 28 states and 9 Union Territories in India. Education is concurrent list in India, an item of concerns of both the Centre and the states. The Ministry of Education and Social Welfare of the central government included the Educational Technology (ET) Project in the Fifth Five Year Plan in 1971. The National Policy of Education (NPE 1986, p.22) stated that "ET will be employed in the spread of the useful information, the training and the retraining of teachers, to improve quality education, sharpen awareness of art and culture, and inculcate abiding values etc., both in the formal and non-formal sectors". The revised NPE, 1992 also laid emphasis on the use of educational technology for improving both "quality" and "quantity" of education. National Education Policy (NEP), 2020, clause 23.3. stated that "Use and integration of technology to improve multiple aspects of education will be supported and adopted, provided these interventions are rigorously and transparently evaluated in relevant contexts before they are scaled up" (NEP 2020 p.56). In the field of education, the use of computer, smart phones, LCD Projector and Internet technology becomes a useful tool for data creation, store, and share or transmit, exchange information etc., and Educational Technology (ET) then converted into ICT. The spread of covid-19 reveals the importance of ICT integration in Teaching and learning and teachers and students across the country are forced to use ICT by this pandemic.

The following tables show number of schools in Mizoram for 2020-21.

Table 3.1: Primary Schools in Mizoram

Sl/No	Districts	Primary School				
		Govt.	Aided	Private	Central	Total
1	Aizawl	217	0	198	2	**417**
2	Champhai	76	0	49	1	**126**
3	Hnahthial	48	0	22	0	**70**
4	Khawzawl	40	0	25	0	**65**
5	Kolasib	86	0	50	0	**136**

6	Lawngtlai	227	0	87	0	**314**
7	Lunglei	205	0	92	1	**298**
8	Mamit	142	0	54	0	**196**
9	Siaha	118	0	13	0	**131**
10	Saitual	57	0	35	0	**92**
11	Serchhip	66	0	45	0	**111**
Mizoram		**1282**	**0**	**670**	**4**	**1956**

Source : UDISE + 2020-21

Table 3.2: Upper Primary Schools in Mizoram

Sl/No	Districts	Upper Primary				
		Govt.	Aided	Private	Central	Total
1	Aizawl	166	23	172	3	**364**
2	Champhai	61	5	47	1	**114**
3	Hnahthial	30	6	17	0	**53**
4	Khawzawl	37	0	21	1	**59**
5	Kolasib	72	5	40	1	**118**
6	Lawngtlai	157	0	55	1	**213**
7	Lunglei	138	19	57	2	**216**
8	Mamit	103	7	33	1	**144**
9	Siaha	78	0	12	0	**90**
10	Saitual	53	0	33	0	**86**
11	Serchhip	53	9	35	2	**99**
Mizoram		**948**	**74**	**522**	**12**	**1556**

Source : UDISE + 2020-21

As seen in table 3.1, there are 1282 Government Primary schools in Mizoram. Among all the districts of Mizoram Lawngtlai district has the highest government primary schools while Khawzawl district has the lowest government primary schools in Mizoram. There is no aided primary school in Mizoram.

There are 670 private primary schools in Mizoram. Among all the private primary schools, Aizawl district has the highest number of private primary schools while Siaha district has the lowest number of private primary schools in Mizoram. There are only 4 central primary schools in Mizoram. Aizawl District has 1 central primary school, Champhai and Lunglei district has 1 each central primary school in Mizoram. According to the report of UDISE plus 2020-21 data, there are 1956 primary schools in Mizoram.

Table 3.2 also shows that there are a total of 1556 upper primary schools in Mizoram. There are 948 government upper primary schools out of which majority 166 government upper primary schools are located in Aizawl District. Hnathial District has 30 upper primary schools in Mizoram which is the lowest. There are 74 Aided upper primary schools in Mizoram. Aizawl District has the highest aided upper primary schools in Mizoram while 4 Districts i.e., Khawzawl, Lawngtlai, Siaha and Saitual district have no aided upper primary schools in Mizoram.

There are 522 private upper primary schools in Mizoram. Among all the private upper primary schools in Mizoram majority of the schools are situated in Aizawl District while less number of private upper primary schools is situated in Siaha District. There are only 12 central upper primary schools in Mizoram. Aizawl District has the highest central primary schools while Hnahthial, Siaha and Saitual district have no central upper primary schools.

Altogether, there are 3512 Primary and Upper Primary schools in Mizoram according to the reports made by Udise plus 2020-21 data.

Table 3.3: Secondary Schools in Mizoram

Sl/No	Districts	Secondary School				
		Govt.	**Aided**	**Private**	**Central**	**Total**
1	Aizawl	63	31	102	3	**199**
2	Champhai	21	18	15	1	**55**
3	Hnahthial	12	6	4	0	**22**
4	Khawzawl	9	5	14	1	**29**
5	Kolasib	26	10	10	1	**47**
6	Lawngtlai	29	5	31	1	**66**
7	Lunglei	43	17	35	2	**97**
8	Mamit	31	11	15	1	**58**
9	Siaha	17	10	13	0	**40**
10	Saitual	24	12	14	0	**50**
11	Serchhip	22	13	13	1	**49**
Mizoram		**297**	**138**	**266**	**11**	**712**

Source : UDISE + 2020-21

Table 3.4: Higher Secondary Schools in Mizoram

Sl/No	Districts	Higher Secondary School				
		Govt.	**Aided**	**Private**	**Central**	**Total**
1	Aizawl	12	8	54	2	**76**
2	Champhai	1	0	8	0	**9**
3	Hnahthial	1	2	5	0	**8**
4	Khawzawl	0	2	3	1	**6**
5	Kolasib	2	2	5	1	**10**
6	Lawngtlai	3	0	18	1	**22**
7	Lunglei	4	1	23	0	**28**
8	Mamit	2	0	3	0	**5**
9	Siaha	1	0	10	0	**11**
10	Saitual	3	1	6	0	**10**

11	Serchhip	2	3	7	1	**13**
Mizoram		**31**	**19**	**142**	**6**	**198**

Source : UDISE + 2020-21

Table 3.3 shows that there are 712 secondary schools in Mizoram. Among all the 712 secondary schools in Mizoram, there are 297 government secondary schools. Khawzawl District has only 9 government secondary schools which are the lowest among all the districts of Mizoram. There are 138 government aided secondary schools in Mizoram. Among all the aided secondary schools in Mizoram, Khawzawl and Lawngtlai Districts have less number of aided schools. There are 266 Private secondary schools in Mizoram. Among all the private secondary schools, Hnahthial District has least private secondary schools. There are only 11 central secondary schools in Mizoram. Hnahthial, Siaha and Saitual Districts have no Central secondary schools. Among all the district of Mizoram, Aizawl District has the highest number of Government, Aided, Private and Central secondary schools in Mizoram.

Table 3.4 shows that that there are 198 Higher Secondary schools in Mizoram. Among all the districts of Mizoram, Mamit District has the lowest higher secondary schools in Mizoram. There are 31 government higher schools in Mizoram. Khawzawl district has no government higher secondary schools. There are also 19 Aided higher secondary schools in Mizoram. Champhai, Mamit and Siaha districts have no aided higher secondary schools. There are 142 private higher secondary schools in Mizoram. Khawzawl and Mamit districts have the lowest number of private secondary schools in Mizoram. There are only 6 Central higher secondary schools in Mizoram. Among all this type of higher secondary schools in Mizoram, Aizawl district has the highest number of higher secondary schools in Mizoram.

A study in ICT is to provide a huge success of learning for teachers and students in many different ways. From various countries, many researchers have been studying ICT in a multidisciplinary form. Among different stages of Institutions of the World, various researchers had a vital finding in ICT for mathematics education. The findings of research in ICT have deeply impact mathematics education in a positive ways. They also give answers to unresolved problems in the field of mathematics education.

Education around the world is trying to incorporate ICT in teaching learning process to develop high order thinking skills and to impart knowledge among students. Information communication technology is a versatile instrument as it has the capability not only to engage students in instructional activities to increase their learning, but also helping them in solving complex problems to enhance their cognitive skills. "ICT-supported learning environments could be beneficial to a constructivist teaching approach which will be helpful to students in their development" (Guma, Faruque and Muhammad, 2013). United Nations Educational, Scientific and Cultural Organization (UNESCO, 2010) defines ICT as the forms of technology that are used to transmit, process, store, create, display, share or exchange information by electronic means (Edumadze, 2015). ICT consist of the hardware, software and media for collection, storage, processing, transmission and presentation of information and related services (Karoline & Celine, 2016). The National Policy on ICT (2012) focused on use of ICT in School Education to devise, support, catalyze, and sustain ICT. It promotes the ICT enabled activities and processes in order to improve access, quality and efficiency in the school system (Singh, 2019).

The integration of ICT in the classroom teaching-learning is very important as it provides opportunities for teachers and students to store, manipulate, and retrieve information, encourage independent and active learning, motivate teachers and students to continue learning outside school hours. It also helps to prepare and plan lessons and design study materials and effective delivery of such materials. ''There is a worldwide need felt for integrating ICT into education in order to improve the pedagogy to reflect the societal change'' (Plomp et al, 2007).

Use of ICT in education develops higher order skills such as collaborating across time and place and solving complex real world problems (Mason-2000, Lim and Hung-2003, Bhattacharya and Sharma-2007). Thus ICT can be used to prepare the workforce for the new global economy and information society (Kozma, 2005). E-education can provide access to the best gurus and the best practice or knowledge available (UNESCO, 2000). The globalization process has always created a large market of offshore students. To reach them, information technology is the only convenient medium, which can offer education as a service (Bhattacharya and Sharma-2007) (Charles, 2012) have found that access to technological resources is one of the effective ways to teachers' pedagogical use of ICT in teaching which ends up into bringing a change in students' behavior and performance.

There are also a number of difficulties which act as barriers and prevent integration of ICT into the classroom. As (Jones, 2010) defines, a barrier is that which makes the things difficult to happen. Pauland and Mondal (2012) found out that there is significant association between ICT and the quality of secondary education. The main barriers of using ICT in schools were lack of financial resources, poor access to the internet, limited trained teachers, and lack of policy for using ICT in teaching-learning process (Kumar, 2015). Lack of funding, lack of ICT integration and lack of connectivity were found to be the most critical barriers to the use of ICT in secondary schools. Teacher's personal factors such as proficiency in computers, computer experience, and time spent on computers, internet connection at home and ownership of computer had influence on barrier factors (Prasad et al., 2015).

3.1 Need for the Study

Nowadays, ICT has become an integral part of teaching learning process, but it is not always workable in most of the schools in Mizoram. National policy on ICT for school education came into being in 2013 in India. But schools are still unable to implement the recommendations of the policy. Teachers are unable to evolve effective instructional material to cope with the emerging trends in the curriculum and pedagogy due to many constraints. The importance of ICT in Education can be seen during covid-19 pandemic. Teachers are compelled to use ICT tools for content creation, delivery and assessment during pandemic. The importance of ICT will remain the same for post covid-19 pandemic. The present study is an effort to identify the availability of ICT and the barriers for effective use of ICT in Teaching and Learning in schools within Mizoram state.

3.2 Objectives

1) To study the availability of ICT in schools.
2) To study access related barriers in the use of ICT in schools.

3.3 Methodology

The present study is descriptive study and a questionnaire was developed for the Head of institutions under School Education Department, Government of Mizoram. The questionnaire included items related to availability and barriers of ICT integration in teaching learning process in schools. Same questionnaire was originally developed in English. It was translated to Mizo language. The English version was given to Secondary schools and Mizo version was distributed to elementary schools. The questionnaire was created using Google form and distributed through the Education Department, by requesting Director of School Education, Government of Mizoram, to convey the questionnaire to the Head of Institution through the concerned District Education Officers' and Sub-Divisional Education officers. Due to Covid-19 pandemic, questionnaire cannot be distributed in physical and so, email and Whatsapp were utilized for distributing the Google form using a link.

3.4 Population of the study

There are 4422 schools from Primary schools to Higher Secondary schools in Mizoram state in 2020-21 as per Udise Plus data (Table 1 and 2 above). Out of these 3512 are Elementary (1956 is Primary Schools and 1556 Upper Primary schools) and 910 are Secondary Schools (712 Secondary and 198 Higher Secondary schools).

There are 33 Central schools which are not under the Government of Mizoram. Besides 748 elementary schools within Lawngtlai and Siaha districts are under District council administration and so, they are not included in the study. So, the total schools under study are 3641 schools. The study was carried out during July to September, 2021. 1490 schools responded the questionnaire which is 40.90% of the population under study.

3.5 Statistical Treatment of Data

For the analysis of the collected data, descriptive statistics like percentage was used. MS Excel 2010 was used for data analysis.

3.6 Analysis and interpretation of the data.

The data were analyzed and interpreted as follows:

Table 3.5: Availability of ICT tools in Schools

AVAILABILITY OF TOOLS IN SCHOOLS							
Sl.No.	QUESTIONS	Elementary		Secondary		All (Elementary and Secondary)	
		YES	NO	YES	NO	YES	NO
1	Does your school have Electric connection?	797 (78.3%)	221 (21.7%)	451 (95.6%)	21 (4.4%)	1248 (83.7%)	242 (16.2%)
2	Does your school have computer or laptop?	499 (49%)	519 (51%)	399 (84.5%)	73 (15.5%)	898 (60.2%)	592 (39.7%)
3	Does your school have LCD Projector?	42 (4.1%)	976 (95.9%)	174 (36.9%)	298 (63.1%)	216 (14.5%)	1274 (85.5%)
4	Does your school have internet connection?	54 (5.3%)	964 (94.7%)	124 (26.3%)	348 (73.7%)	178 (11.9%)	1312 (88%)
5	Does your school have interactive board?	87 (8.5%	931 (91.5%)	141 (29.9%)	331 (70.1%)	228 (15.3%)	1262 (84.7%)

6	Does your school have educational software (Freeware or licensed)?	12 (1.2%)	1006 (98.8%)	39 (8.3%)	433 (91.7%)	51 (3.4%)	1439 (96.5%)
7	Does your school have smart classroom or ICT enable classroom?	76 (7.5%)	942 (92.5%)	66 (14%)	406 (86%)	142 (9.5%)	1348(90 .4%)
8	Does your school have YouTube channel for education?	18 (1.8%)	1000 (98.2%)	37 (7.8%)	435 (92.2%)	55 (3.6%)	1435 (96.3%)
9	Does your school have WhatsApp group for teaching-leaning ?	731 (71.8%)	287 (28.2%)	458 (97%)	14 (3%)	1189 (79.8%)	301 (20.2%)
10	Does your school have Social Media (Facebook?	51 (5%)	967 (95%)	110 (23.3%)	362 (76.7%)	161 (10.8%)	1329 (89.1%)
11	Does your school have computer room or lab?	65 (6.4%)	953 (93.6%)	277 (58.7%)	195 (41.3%)	342 (22.9%)	1148 (77.0%)

As found in table 3.5, most of the schools have electric connection (power supply), 242 schools (16.2%) does not have power supply. 60.2% possess computer or laptop. Only 14.5% possess LCD projector. 11.9% have internet connection and 15.3% have interactive board. Almost all the schools do not have educational software, only 3.4% have educational software. Only 9.6% have ICT enabled classroom. A very few schools have YouTube channel (3.6%). However, most of the schools have WhatsApp group for teaching-learning. Only 10.8% are using Facebook / Instagrams and 22.9% have computer room or lab.

Access to the technology (software and hardware both) itself is the most important component in the use of ICT and the data revealed that internet and software/hardware are not available to the desired extent. Computers were available but teachers reported that accessories required for ICT integrated teaching and learning are not available in most schools. Majority of the schools have either no or disruptive internet connectivity which makes the use of ICT difficult especially during the covid-19 pandemic.

Although the government is emphasizing ICT integration in the teaching learning process at all levels but the responses of the teachers reveal that there is still a dearth of ICT related infrastructure including computer labs and smart classrooms.

Table 3.6: Barriers of using ICT in Schools

BARRIER OF USING ICT IN SCHOOLS									
Sl. No	**Questions**	**Not a barrier**		**Small barrier**		**Moderate barrier**		**Great barrier**	
1	Not enough computers	127	8.5%	160	10.7%	540	36.2%	663	44.5%
2	Outdated, incompatible or unreliable computers	207	13.9%	221	14.8%	477	32.0%	585	39.3%
3	Lack of adequate skills of teachers.	406	27.2%	338	22.7%	519	34.8%	227	15.2%
4	Insufficient number of the interactive whiteboard or any other educational software	174	11.7%	206	13.8%	513	34.4%	597	40.1%
5	Inadequate training is given to the teachers for using ICT in the Classroom	169	11.3%	256	17.2%	575	38.6%	490	32.9%
6	Restrictive time table	621	41.7%	347	23.3%	404	27.1%	118	7.9%
7	Lack of administrative support	434	29.1%	293	19.7%	523	35.1%	240	16.1%
8	Lack of technical support or device	208	14.0%	292	19.6%	557	37.4%	433	29.1%
9	Lack of confidence regarding the use of ICT	481	32.3%	415	27.9%	445	29.9%	149	10.0%
10	Lack of funding	100	6.7%	144	9.7%	521	35.0%	725	48.7%

11	Using ICT in teaching and learning not being a goal of the school	598	40.1%	421	28.3%	368	24.7%	103	6.9%
12	Lack of flexibility due to time constraint and over load of work	419	28.1%	451	30.3%	478	32.1%	142	9.5%
13	Insufficient number of internet connected computers	104	7.0%	111	7.4%	334	22.4%	941	63.2%
14	The pressure to prepare students for exams and tests	475	31.9%	387	26.0%	480	32.2%	148	9.9%
15	Inadequate space and infrastructural facilities	233	15.6%	214	14.4%	499	33.5%	544	36.5%
16	No or unclear benefit of using ICT for teaching	600	40.3%	348	23.4%	414	27.8%	128	8.6%
17	Lack of interest of teachers	823	55.2%	283	19.0%	290	19.5%	94	6.3%

As seen from the above Table 3.6, the main barriers of using ICT in schools are - Lack of funding, insufficient number of internet connected computers and not enough computers.

Next to main barriers are - Insufficient number of the interactive whiteboard or any other educational software, outdated, incompatible or unreliable computers, Inadequate space and infrastructural facilities, inadequate training is given to the teachers for using ICT in the classroom, lack of technical support or advice, lack of administrative support, lack of adequate skills of teachers, lack of confidence regarding the use of ICT, the pressure to prepare students for exams and tests, lack of flexibility due to time constraint and overload of work.

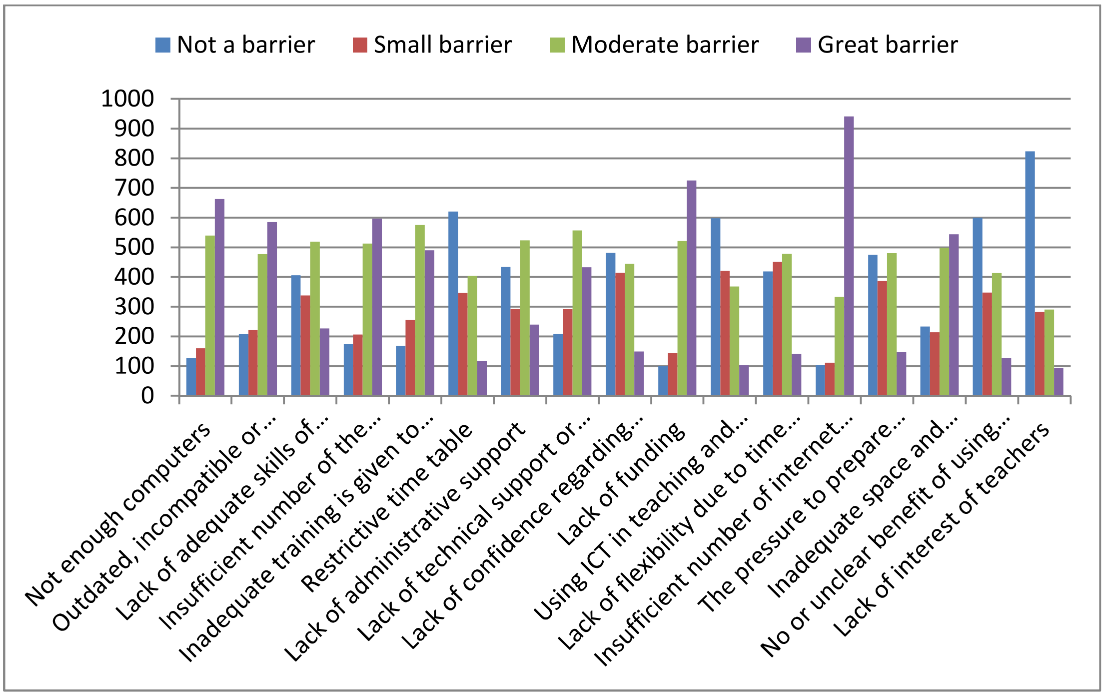


Figure 3.1: Bar graph representation of table 3.6**:** Barriers of using ICT in Schools

Least barrier includes - No or unclear benefit of using ICT for teaching, restrictive time table, using ICT in teaching and learning not being a goal of the school, lack of interest of teachers.

Table 3.7: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.898
Bartlett's Test of Sphericity	Approx. Chi-Square	7037.177
	df	91
	p-vlaue	0.0001

Table 3.7 shows the values of Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) and Bartelett's test of sphericity. The value of Kaiser-Meyer-Olkin for MSA is found as 0.898 and indicating that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors. Bartlett's test is highly significant ($p<0.001$) and therefore factor analysis is appropriate as

there are some relationships between the variables included in the factor analysis model.

Table 3.8: Communalities

Variable	Initial	Extraction
Not enough computers	0.470	0.512
Outdated, incompatible or unreliable computers	0.436	0.449
Insufficient number of the interactive whiteboard or any other educational software	0.333	0.378
Restrictive time table	0.395	0.443
Lack of technical support or advice	0.421	0.475
Lack of confidence regarding the use of ICT	0.421	0.471
Lack of funding	0.369	0.403
Using ICT in teaching and learning not being a goal of the school	0.409	0.453
Lack of flexibility due to time constraint and overload of work	0.430	0.499
Insufficient number of internet connected computers	0.381	0.438
The pressure to prepare students for exams and tests	0.378	0.432
Inadequate space and infrastructural facilities	0.265	0.280
No or unclear benefit of using ICT for teaching	0.391	0.449
Lack of interest of teachers	0.352	0.389

Table 3.8 shows that the values of communalities of the variables before and after extraction. It is known that the communality of variable is the total amount of variance shared with the other variables. The communality of not enough computers is 0.512 and it infers that 51.2% of the variance associated with not enough computers is shared with other variables. Similarly, 44.9%, 37.8%, 44.3%, 38.9% of the variances associated with outdated, incompatible or unreliable computers, insufficient number of the interactive whiteboard or any other educational software, restrictive time table, lack of interest of teachers respectively are shared with other variables.

Table 3.9: Total Variance Explained

Factor	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.921	35.152	35.152	4.358	31.128	31.128	3.307	23.619	23.619
2	2.266	16.183	51.335	1.712	12.230	43.358	2.763	19.739	43.358
3	0.867	6.193	57.528						
4	0.742	5.299	62.826						
5	0.716	5.114	67.940						
6	0.658	4.698	72.639						
7	0.565	4.034	76.672						
8	0.552	3.945	80.618						
9	0.506	3.611	84.229						
10	0.480	3.428	87.656						
11	0.471	3.365	91.022						
12	0.464	3.311	94.333						
13	0.434	3.098	97.431						
14	0.360	2.569	100.000						

Table 3.9 lists the eigenvalues associated with each linear factor before extraction, after extraction and after rotation. Before extraction, as same as number of original variables i.e., 14 factors are identified within the data set. The eigenvalues associated with each factor represents the total variance explained by that particular factor and it is also expressed in terms of percentage of variance explained and cumulative percentage. The first factor i.e., not enough computers explains 35.152% of the total variance and similarly 16.183% of variance is explained by second factors and so on. It is clear that the first two factors explain relatively large amounts of variance whereas subsequent factors explain only small amounts of variance.

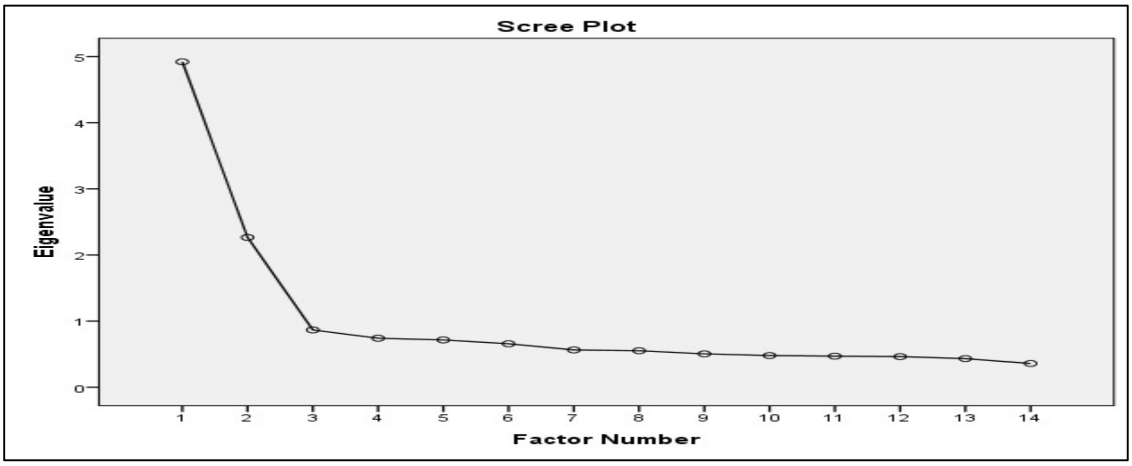


Figure 3.2: Scree plot

Table 3.10: Reliability Test and Rotated Factor Matrix[a]

Variable	Factor	
	1	2
Cronbach's Alpha	0.848	0.971
Lack of flexibility due to time constraint and overload of work	0.694	
No or unclear benefit of using ICT for teaching	0.667	
Lack of confidence regarding the use of ICT	0.666	
Using ICT in teaching and learning not being a goal of the school	0.649	
The pressure to prepare students for exams and tests	0.640	
Restrictive time table	0.631	
Lack of interest of teachers	0.621	
Not enough computers		0.715
Outdated, incompatible or unreliable computers		0.667
Insufficient number of internet connected computers		0.654
Lack of funding		0.618
Lack of technical support or advice		0.596
Insufficient number of the interactive whiteboard or any other educational software		0.589

In table 3.10, the two coefficients displayed show that the good reliability of the two factors. Finally, two factors are associated as barrier towards online training. Two factors are named as Personal and institutional.

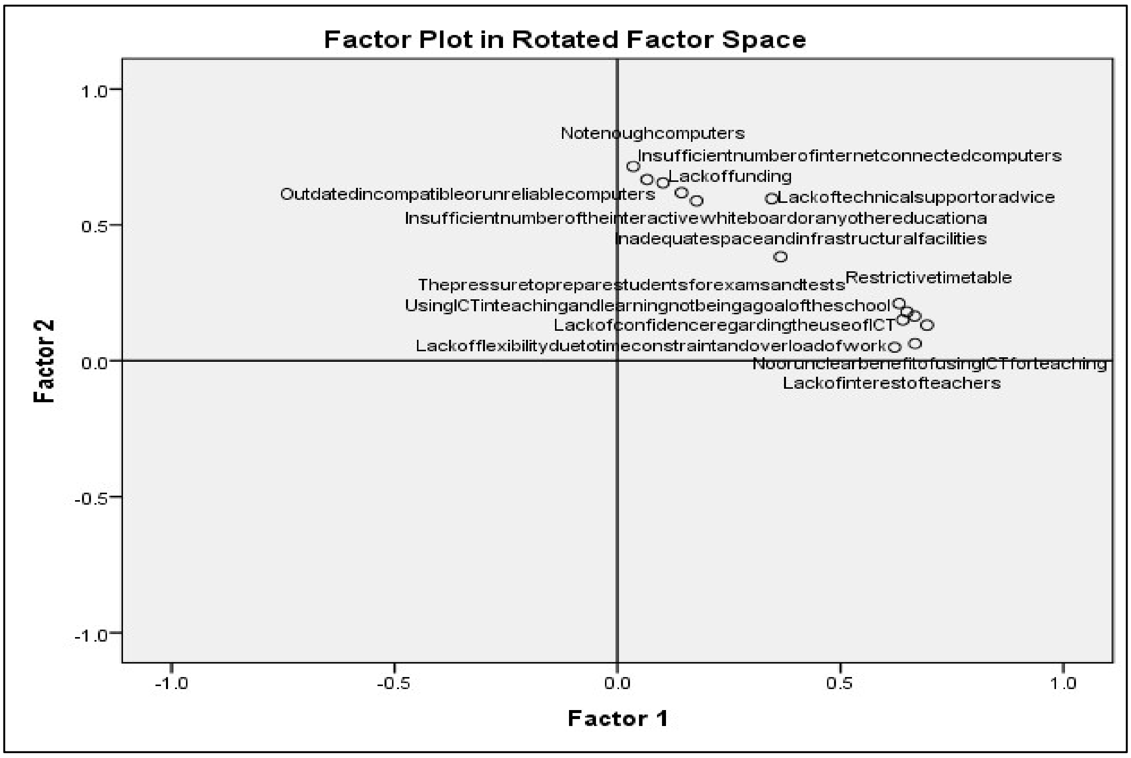


Figure 3.3: Component plot in rotated space

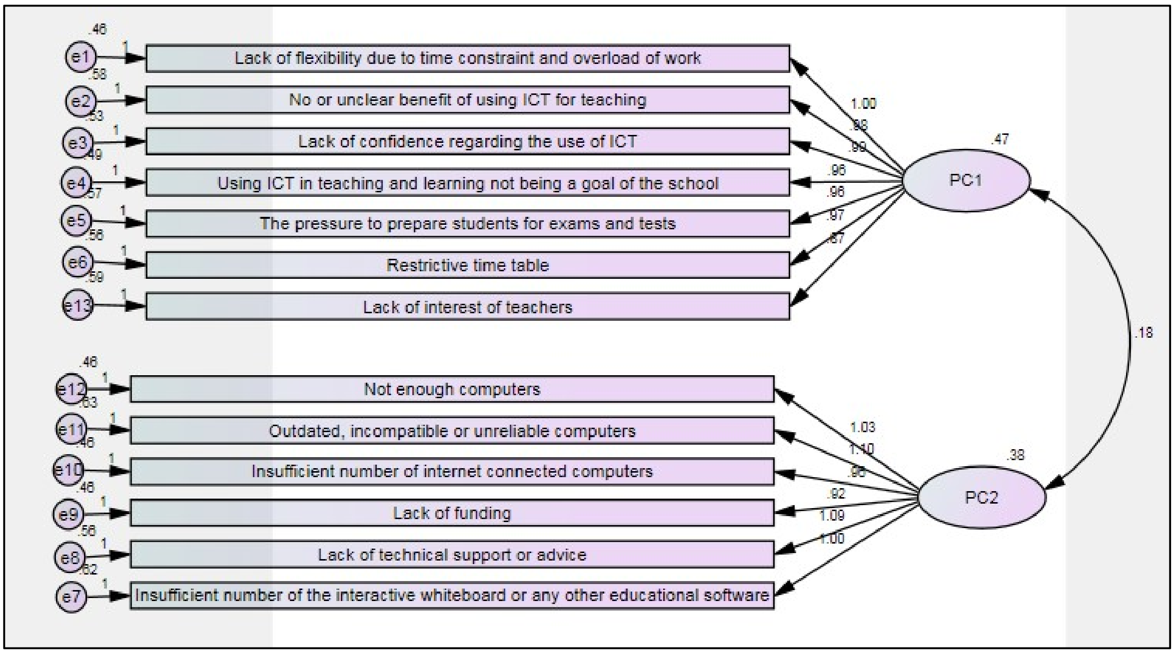


Figure 3.4: Factor Diagram (rotated solution).

In factor 1, 7 variables have shown higher loadings. All the variables indicate about personal barrier, according to the response of the participants. So, it can be named as 'Personal'. Lack of flexibility due to time constraint and overload of work, no or unclear benefit of using ICT for teaching, lack of confidence regarding the use of ICT, using ICT in teaching and learning not being a goal of the school, the pressure to prepare students for exams and tests are the problems of the participants. Due to the restricted time table, the teachers may also lack the interest of teaching as e-learning is new to them. In factor 2, not enough computers, outdated, incompatible or unreliable computers, insufficient number of internet connected computers, lack of funding, lack of technical support or advice, insufficient number of the interactive whiteboard or any other educational software and inadequate space and infrastructural facilities are barriers towards the institution.

3.7 Conclusion

Though the study do not covers all the schools in Mizoram, but this is the mirror that reflects the trend in most schools regarding ICT integration in teaching learning process in Mizoram.

As far as institutional barriers are concerned, enough computers, internet connection, and technical support will facilitate them to overcome barriers to participate online learning. The government seems to have good intention but infrastructural provision is not as excellent as intended for the appropriate use of ICT.

Implementation of the ICT Policy of School Education seems to be a distant dream unless adequate infrastructure, hardware/software is made available in the schools. Another important factor is the personal lack of confidence regarding the use of ICT. So, Proper training is also required for making ICT effective in education because the technologies are changing very fast.

3.8 Implications

The finding of this study implies that the schools should make sure that computer labs and smart classrooms are made functional.

The government should allocate funds so that the required software/hardware and digital devices are provided to the schools for the effective use of ICT.

School Education Department should arrange the training programs at frequent intervals so that the teachers can make better use of changing technologies.

The government should have a very strong will to provide all financial and administrative support to ensure the use of ICT in schools as an effective tool for teaching learning which will be needed even after the covid-19 pandemic.

CHAPTER 4

EFFECTIVENESS OF ICT ON ONLINE MATHEMATICS TEACHING AND LEARNING IN SECONDARY SCHOOLS OF MIZORAM DURING COVID-19 PANDEMIC

4.0 Introduction

Since ICT has become such an important feature in the everyday life, it is no wonder that it has also burrowed through the teaching and learning scenario making its presence felt in more ways than one. The coming of the COVID-19 pandemic, though a calamity in itself, provided an opportunity find out that the true effectiveness of using ICT in online mathematics teaching and learning (Pillay & Naidoo, 2020). The population under consideration was secondary teachers teaching mathematics. The findings clearly outlined the status of mathematics teacher when it came to the teaching of mathematics using ICT. It was also considered necessary to get a little bit of information regarding the profile of teachers at this stage. It was found out that a strong majority of the teachers were male. It was found that nearly half of the mathematics teachers did not have computers of their own. The study also found that only about half of them had received training in ICT. A large majority of them did not enjoy teaching through ICT. Majority of them were of the general opinion that mathematics teaching has suffered due to online mode but it could still be used as a supplement to offline mode of teaching. Teachers were also of the opinion that not all of their students had the facility to make full use of ICT to learn mathematics. Moreover, they did not consider that students showed improvement due to online mode of teaching, strongly indicating a general disapproval of online mode of teaching. In a nutshell, it was discovered that mathematics educators did not consider ICT adequate to replace offline teaching but they considered that it could supplement it. Besides this, it was also felt that students themselves enjoyed teaching enhanced with ICT.

ICT is an important part of today's world. In the world of education, regardless of the subject being taught, it is gaining importance with each passing year (Kulik & Kulik, 1991). Especially in light of the fact that teaching is a profession that needs professionals who are able to impart the needed resources for the nation, it is imperative that ICT becomes a part of teaching from the lowest levels so that students are exposed to technology from an early age (Cher and David, 2003). For this to be made a possibility, teachers have to be ready to use technology, and technology itself has to be available (Kul et al., 2018). But another important part of this is that even students, who are at the receiving end have to be ready to receive knowledge through this medium, meaning they need to be aware of the need to have the much needed facilities if ICT is used in a remote manner, and connectivity also has to be enabled so that two way communication is enabled.

School Education in Mizoram is categorized broadly as Elementary and Secondary. Elementary (Primary school and Middle school) covers classes 1 to 8 and Secondary (high school and higher secondary school) covers classes 9 to 12. High School cover classes 9 and 10 and Higher Secondary School cover classes 11 and 12. As per Udise plus 2020-21 data, there are 712 High Schools with 4306 teachers and 40037 students, 198 Higher Secondary Schools with 1900 teachers and 24966 students.

4.1 Covid-19 pandemic and online education using ICT

Covid-19 is a pandemic that affects the education system of different income level countries (Wajdi et al., 2020). Corona virus affects the education system in the world. Schools, colleges, and universities are closed to control the spread of the covid-19. Closer of educational institution brings difficulties for students, teachers, and parents. So, distance learning is a solution to continue the education system (Tadesse and Muluye, 2020). UNESCO had recognized that the covid-19 pandemic outbreak has impacted education around the globe and reported that 87% of the world's students were affected by school closures. According to the UNESCO, over 1.5 billion students in 195 countries are affected by COVID-19 pandemic school closures (UNESCO, 2020).

The pandemic crisis increases social inequality in schools. Pupils from more advantaged parents attend online class with better digital equipment. A large number of students are attending online class with lower ICT equipment and educational resources (Di Pietro et al., 2020). Institution in urban areas continued teaching in online mode by uploading assignments, books, and reading materials, using Google Classroom, social media, e-mail and other available applications. Some schools are sending study materials directly to students through social media platforms. It was seen that there is a difference between urban and rural schools and the private and public schools to keep their students learning from their home. A large number of teachers and students have limited access or no access to the internet (Tzifopoulos, 2020).

In Mizoram the first case of corona virus was confirmed on 24 March, 2020. On 15th March 2020, the state government announced to observe 14 days quarantine for people coming home from outside the state. On 22nd March, after Janata Curfew was observed in the whole of India, the state government declared a total lockdown. Under the conditions of total lockdown, educational institutions were shut down. Teachers and students could no longer avail the traditional modes of teaching and learning. The only way to continue teaching and learning lay in the adoption of ICT in education from a multi-modal dimension. ICT was no longer a mere complementary alternative but became the lone outlet for the continuance of education during Covid-19 period.

Samagra Shiksha, Mizoram conducted a survey on Access to Digital Devices during April-May, 2021 and found out that 38.31% percentage of students are without ICT device across all the sections of School Education (School Education Department, 2021). There are 50.33% of children without device in the Primary section alone as shown in table 4.1 below.

Table 4.1: Table showing students with access to device

Section	Enrolment	Students with Access to Devices (e.g., TV, Mobile Phone, Computer, etc.)	Students without Access to Devices (e.g., TV, Mobile Phone, Computer, etc.)
PRIMARY	50090	24880 (49.67%)	25210 (50.33%)
UPPER PRIMARY	41149	26572 (64.58%)	14577 (35.42%)
SECONDARY	16150	12997 (80.48%)	3153 (19.52%)
HIGHER SECONDARY	7616	6494 (85.27%)	1122 (14.73%)
TOTAL	**115005**	**70943 (61.69%)**	**44062 (38.31%)**

Source : Samagra Shiksha, Mizoram

The Committee constituted by the Government of Mizoram to make suggestions for Improvement of Online Education during Covid-19 pandemic conducted a survey through DEOs and SDEOs on the status of internet connectivity in Mizoram; results show that there are many villages where internet connectivity is an issue as shown in table 4.2 and 4.3 below. Reports of irregular signals and insufficient signal strength coming in the way of online classes are also submitted by many villages.

Table 4.2: Connectivity status at Secondary schools during Covid-19 pandemic

Sl.No	DEO	No. of villages with Internet connectivity Problem	No. of villages with Cable TV Problem
1	Aizawl	Nil	Nil

2	Lunglei	12	1
3	Siaha	17	17
4	Champhai	1	Nil
5	Serchhip	Weak Signals	Nil
6	Kolasib	Nil	Nil
7	Mamit	7 Very weak Signals	7 Weak Signals
8	Lawngtlai	Weak Signals	Nil
9	Hnahthial	Irregular Signals	3
10	Khawzawl	Weak Signals	Nil
11	Saitual	Nil	Nil

Source : Directorate of School Education, Government of Mizoram

Table 4.3: Connectivity status at elementary schools during Covid-19 pandemic

Sl.No	SDEO	No. of villages with Internet connectivity Problem	No. of villages with Cable TV Problem
1	Aizawl East	Nil	Nil
2	Aizawl West	Nil	Nil
3	Aizawl South	Nil	Nil
4	Darlawn	4	8
5	Saitual	Nil	2
6	Lunglei North	3	15
7	Lunglei South	10	20
8	Lungsen	25	52
9	Hnahthial	Irregular Signals	1(+)
10	Serchhip	Nil	3

11	Thenzawl	Nil	Nil
12	North Vanlaiphai	Weak Signals	Nil
13	Champhai	9	4
14	Khawzawl	Weak Signals	Nil
15	Kolasib	3	11
16	Kawnpui	Nil	5
17	Mamit	2	3
18	Kawrthah	Irregular Signals	13
19	West Phaileng	19	3
20	Ngopa	Weak Signals	1

Source : Directorate of School Education, Government of Mizoram

Indications derived from these two Surveys are proof that there is a technological divide that acts as barrier to learning and the government decided that the barrier needs to be bridged with sound guidelines for online, partially online and offline education to help teachers reach the last child in the last mile using multiple modes - portal, apps, telecast/broadcast, Websites, YouTube, print resources, textbooks, supplementary learning materials and more.

There are a lot of problems and confusion on the parts of the students as well as the teachers in online teaching during covid-19 pandemic, as this is done without proper training, for smooth functioning of online learning it will need proper training and resources. So, the teachers are in a stage of experimenting and trying their best for their students (Mishra et al. 2020). Students experienced dramatic change in mathematics education during the enforced Covid-19 lockdown and there needs to be quality support for students and teachers in the transition (Calder et.al., 2021). The training received for online teaching, the mismatch between pedagogy and learning styles of students, work-life balance pressure and assumptions about home life conditions, connectivity and availability of devices are the constraints to online teaching and learning (Singh et al., 2021). The lockdown situation is certainly an obstacle to the progress of education and mathematics education since most students do not have enough necessary devices (Das, 2021). During the Covid-19 pandemic, students had a positive mathematics self-concept, mathematics anxiety was at a moderate level, and already had mathematics self-regulated learning at a low level (Delima and Cahyawati, 2021). Digital learning environments will be with us forever, such that professional development and teacher preparation programs in mathematics education must focus on the implementation of the digital learning environment (Chirinda et.al.,2021). Instructional technology, as a research held with several sub-divisions, has played a major role in cushioning the elect of this pandemic on educational activities by serving as the only platform for instructional design, delivery and assessment platforms (Adedoyin and Soykan, 2020). A Covid-19 crisis ushered in digital teaching and learning experiences that clearly spelt out the existence of digital instructional and pedagogical gaps in mathematics education (Mukavhi & Brijlall, 2021). The covid-19 pandemic has severely hit the academic sector due to the lack of proficiency in online teaching mode due to the technological and infrastructural lacuna (Biswas & Rahaman, 2021). The governments must ensure the availability of reliable communication tools, high quality digital academic experience, and promote technology-enabled learning for students to bridge the disparities originated in the education system before and after COVID-19 catastrophe which is also inevitably necessitated for uninterrupted learning (Mishra et al., 2020). Before using digital platforms for mathematics learning, it is important for students to be encouraged to practice and engage collaboratively within digital platforms (Naidoo, 2020). There is a need for secondary schools, with the help of the government and other stakeholders to promote the establishment of e-learning facilities countrywide (Mukuka et al., 2021).

Due to COVID-19 pandemic, schools have been totally closed in Mizoram. There are no other alternatives and so teaching and learning during this pandemic can be carried out using online mode only. With all these factors in mind, a state-wide research was done with the following objectives.

4.2 Objectives of study

1. To study the challenges faced by the students and teachers of secondary schools in Mizoram on teaching and learning Mathematics during Covid-19 pandemic.

2. To find out the effectiveness of ICT on online Mathematics teaching and learning at secondary level of education in Mizoram during covid-19 pandemic.

4.3 Research questions

The study was guided by the following questions:

(i) What is the effectiveness of using ICT for online teaching process of Mathematics in the secondary school of Mizoram during Covid-19 pandemic?

(ii) What are the barriers of using ICT for online Mathematics teaching in secondary school of Mizoram?

4.4 Methodology

This part of the research was descriptive in nature. The population included secondary school teachers teaching mathematics within the state of Mizoram. The Information schedule and opinionnaire were sent out to the entire population. Out of these, 348 teachers responded. Since there was a total of 774 mathematics teachers at the secondary level and 71 mathematics teachers at the higher secondary level in Mizoram, the responses made up 41.1% of the population and was thus considered more than adequate for research. Since no selection was made, samples were completely random in nature. In view of the research objective, the researcher opted for an Information Schedule and Opinionnaire as the main tools. The opinionnaire had a total of three dimensions; each having a set of items in which respondents simply had to opt for a 'yes' or a 'no'. The data received was analyzed in a qualitative manner making use of descriptive statistics.

4.5 Overview of the profile of teachers at Secondary level of education in Mizoram

Based on the Information Schedule that was administered by the researcher himself, it was found that out of the 348 responses that came, male teachers made up 80.2% and only 19.8% of them were females. This in itself clearly proved the disparity that still exists in a state like Mizoram, which is a state in the north eastern part of India, that a subject like mathematics which is a highly abstract subject, is still favored by the male of the population. Out of these, 23.9% from urban and 76.1% rural teachers were identified, and since the data was collected through the online mode using Google form, it showed that both localities had teachers who could deal with online technology. This in itself was a positive finding, strongly giving evidence that rural teachers were not far behind in dealing with ICT at least at this level. Secondary school teachers made up 91.1% of the responses and 8.9% were from Higher Secondary Schools.

4.6 Findings regarding ICT compatibility of teachers

The tool was sub divided on three dimensions in keeping with the research objectives and the pandemic situation which necessitated the use of online platform for teaching. On the dimension of ICT and teacher, there were 10 items. The results obtained were separately analyzed and the following are the findings:

Table 4.4: ICT and Teachers

Sl. No.	ICT and Teacher	YES		NO	
		No.	%	No.	%
1	I have my own computer	193	55.5	155	44.5
2	I have my own smartphone	347	99.7	1	0.3
3	I do not know how to use Computers	42	12.1	306	87.9
4	I know how to use software for making e-content like pdf/slides/word etc	274	78.7	74	21.3
5	I use readymade e-content like pdf/slides/word etc to teach my students	208	59.8	140	40.2

6	I can prepare my own teaching videos for student	268	77	80	23
7	I use readymade videos to teach my students	214	61.5	134	38.5
8	I can make e-content using my phone	228	65.5	120	34.5
9	I have received in-service training in ICT	188	54	160	46
10	It is difficult to carry on teaching using ICT	185	53.2	163	46.8

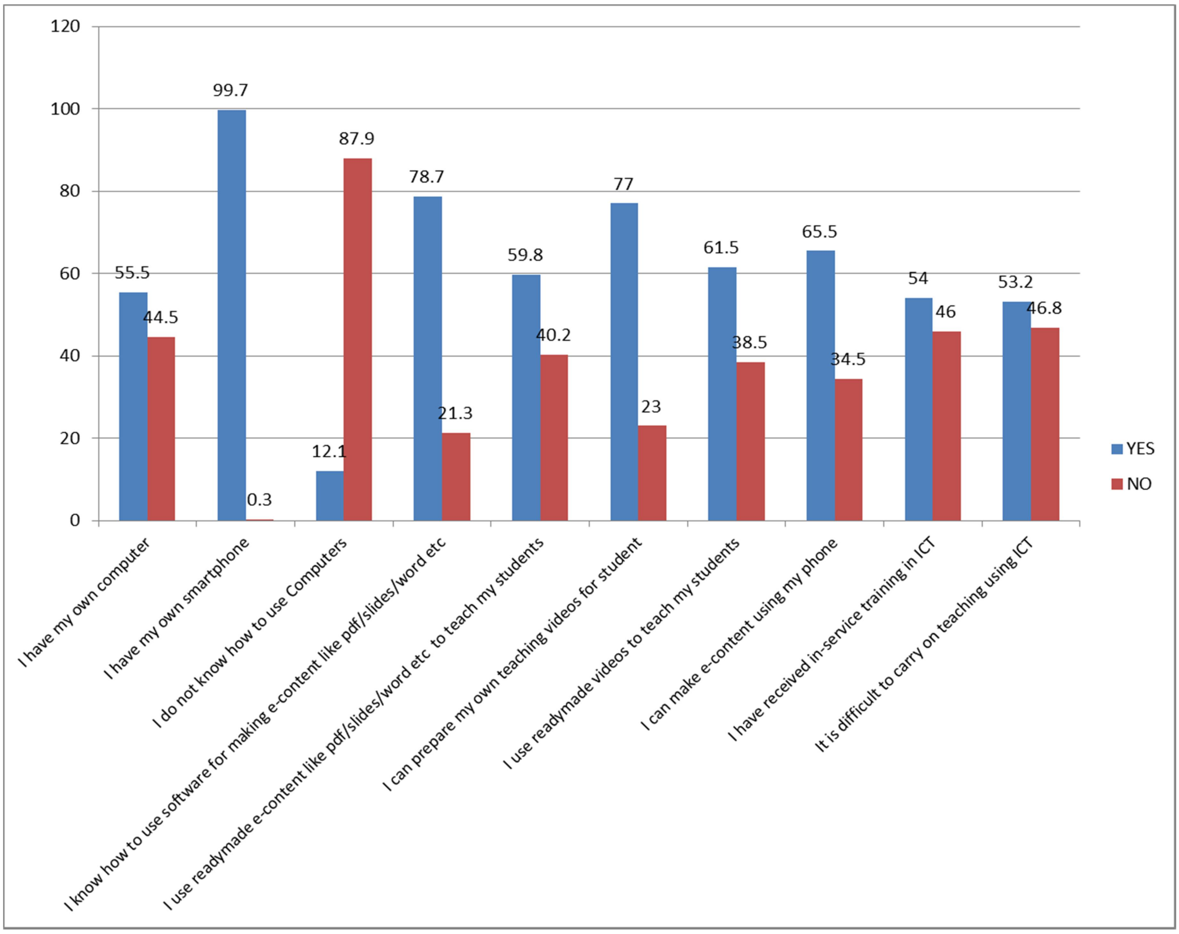


Figure 4.1: ICT and Teachers

The following were the findings regarding ICT compatibility of teachers:

- 55.5% of the sample mathematics teachers had their own computer.
- A small minority of 0.3% among the sample teachers still did not have their own smart phone.
- An unexpected 12.1% of the sample teachers did not know how to use computers, which is an essential part of ICT.
- A majority of them, i.e. 78.7% of the sample teachers could use their software for making e-content.
- A small majority of 59.8% of the sample mathematics teachers could make use of readymade e-content to teach mathematics.
- Among the mathematics teachers who responded, 77% of them claimed to be able to make their own teaching videos.
- Another 61.5% simply made use of ready-made videos.
- A healthy 65.5% of them could make use of their smartphones to make e-content.
- It was noted that only 54% of the sample teachers had received ICT training.
- More than half of the sample teachers i.e. 53.2% still found it difficult to teach using ICT.

4.7 Discussion on findings regarding ICT compatibility of teachers

The above information was considered necessary because the researcher felt that it was important to understand the compatibility of teachers to make use of ICT. The justification for this was that, even if the resources were available, it would not be healthy if teachers could not use the available facilities. The study found that teachers were in very different positions in their compatibility to use ICT. While a good 65.5% of the sample teachers could make their own e-content in their smart phones, there were still nearly 12% of them who did not know how to use a computer, let alone create their own e-content. The fact that only around 54% of the sample teachers had received ICT training revealed the huge backlog when it came to ICT training. Since 53.2% of them still found it difficult to use ICT to teach, it was clear that ICT could not be used as a mandatory part of teaching, in view of the high percentage of teachers who still did not know how to make use of them. The majority of 77% of the teachers who could even make their own teaching videos put the state in a good position but also highlighted that teachers were in a very different positions when it came to ICT compatibility. Also, nearly half of the teacher still did not have their own computers at the time this study was done; this strongly indicates that they did not consider an investment in computer as necessary or wise. This in itself was rather disheartening, because it brought into light the lack of education even among teachers themselves, in the utility of ICT.

4.8 Findings on the status of mathematics teaching during COVID - 19 pandemic according to teachers

The second part of the opinionnaire was concerned with the teaching of mathematics in an online mode which was a necessity during the COVID-19 pandemic.

Table 4.5: Teaching during Covid-19 pandemic

Sl. No.	Teaching during Covid-19 pandemic	YES		NO	
		No.	%	No.	%
1	I do not take online class at all due to non-availability of internet or some other reason	90	25.9	258	74.1
2	During Covid-19 pandemic, classes are taken through online mode only	243	69.8	105	30.2
3	I use Learning Management System (Google classroom, Moodle, Teachmint etc.) for online class	179	51.4	169	48.6
4	I use Google Meet for taking online class	120	34.5	228	65.5
5	I use Zoom for taking online class	109	31.3	239	68.7
6	I use WhatsApp for content delivery	333	95.7	15	4.3
7	I use Facebook for teaching-learning	25	7.2	323	92.8
8	I shared video materials using Youtube	200	57.5	148	42.5
9	I give home-works through emails and WhatsApp	329	94.5	19	5.5
10	I use online classes to teach according to school time table (regularly)	244	70.1	104	29.9
11	I enjoy using ICT for teaching Mathematics	227	65.2	121	34.8

12	Teaching of mathematics through online mode is more preferable than classroom	27	7.8	321	92.2
13	Teaching Mathematics using ICT should be continue to supplement normal classroom teaching even after Covid-19 pandemic	228	65.5	120	34.5
14	Covid-19 pandemic is the barrier for mathematics education	280	80.5	68	19.5

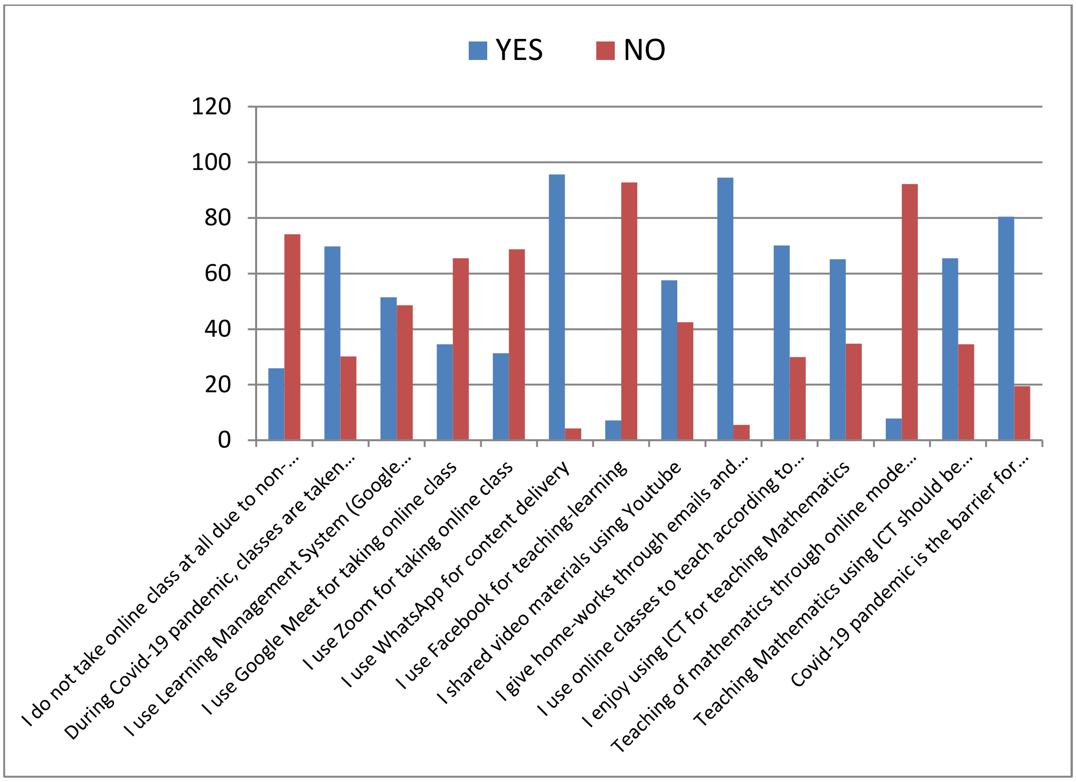


Figure 4.2: Teaching during Covid-19 Pandemic

The following were the findings in various aspects of online mathematics learning:

- It was found that still 25.9% of the sample teachers could not carry on online teaching due to connectivity and other issues.
- A majority of 69.8% could take online classes but still the remaining 30.2 % had to resort to other means.

- It was revealed that slightly more than half of the teachers, 51.4% of the sample teachers could make use of online apps like Teachmint, Google classrooms and Moodle.
- A minority of the teachers, 34.5% of them used Google Meet to teach. Google Meet is a free Internet Application available with good connectivity. It may also be bought and the bought variety carries some packages along with it.
- A slightly lower 31.3% of the teachers used Zoom application to teach mathematics.
- A solid majority of 95.7% of the teachers use Whatsapp, a free online service, to teach.
- A small 7.2% of the teachers use the Facebook Platform to teach.
- A good 57.5% of the teachers shared teaching videos through Youtube.
- Another resounding majority of 94.5% the teachers gave homework through emails and Whatsapp.
- A good but certainly not cent percent, 70.1% of the teachers could carry on teaching through the online mode on a regular basis.
- A fairly good 65.2% of them enjoyed using ICT to teach during the pandemic but
- Only 7.8% of them preferred online teaching to offline mode.
- A small majority of 65.5% of the teachers wanted to supplement offline teaching with online mode even when the pandemic is over and online mode will no longer be a necessity.
- A large 80.5% of the teachers were of the opinion that COVID-19 is a huge barrier to the teaching of mathematics.

4.9 Discussion on findings in various aspects of online mathematics learning

While it was perfectly acceptable and even accepted that majority of the teachers could make use of various online Apps to teach mathematics, it was troublesome to find 25.9% still could not make use of the online mode of teaching due to connectivity issues. Although 70.1% of the teachers were of the opinion that they could continue classes regularly, a larger 80.5% of them still felt that COVID-

19 pandemic was a huge barrier to the teaching of mathematics, clearly indicating that although they could manage online classes they still preferred offline classes. It was not surprising that only 7.8% of them were of the opinion that online mode was better than offline mode. Although 94.5% of them gave home works in the online mode, only 65.2% of them enjoyed using ICT to teach, strongly supporting the fact that knowledge does not necessarily mean enjoyment. A small majority of 65.5% were indeed of the opinion that online teaching should be used as a supplement to offline teaching even when the pandemic is over but clearly many persons in this group belong to the ones who were of the opinion that COVID-19 is a barrier to the teaching of mathematics. All of these responses clearly point to the fact that majority of the teachers, even though they could carry on online teaching, still preferred the traditional classroom teaching and did not consider online mode of teaching as worthwhile if the situation did not demand it.

4.10 Findings regarding teachers' opinion of students learning through ICT during COVID-19 pandemic

The third dimension in the present study covered students who are the most important judge in order to find out the effectiveness of ICT in the teaching of mathematics.

Table 4.6: Students ability to use ICT

Sl No	Students ability to use ICT	YES		NO	
		No.	%	No.	%
1	All my students can access to internet facility	154	44.3	194	55.7
2	All students have at least one mobile phone at home for attending online classes	226	64.9	122	35.1
3	All students know how to use emails, WhatsApp and online classes	251	72.1	97	27.9
4	All students attend online classes regularly	140	40.2	208	59.8
5	No student has a problem with online classes	93	26.7	255	73.3
6	Students' achievements have gone up after online teaching (looking at term exams)	137	39.4	211	60.6

7	Students feel it difficult to understand by teaching mathematics through the internet	298	85.6	50	14.4
8	Students prefer online classes to offline classes	107	30.7	241	69.3
9	There is no difference in the achievement of students before and after online teaching	59	17	289	83
10	Students enjoy ICT enhanced teaching aids even in offline classes	239	68.7	109	31.3

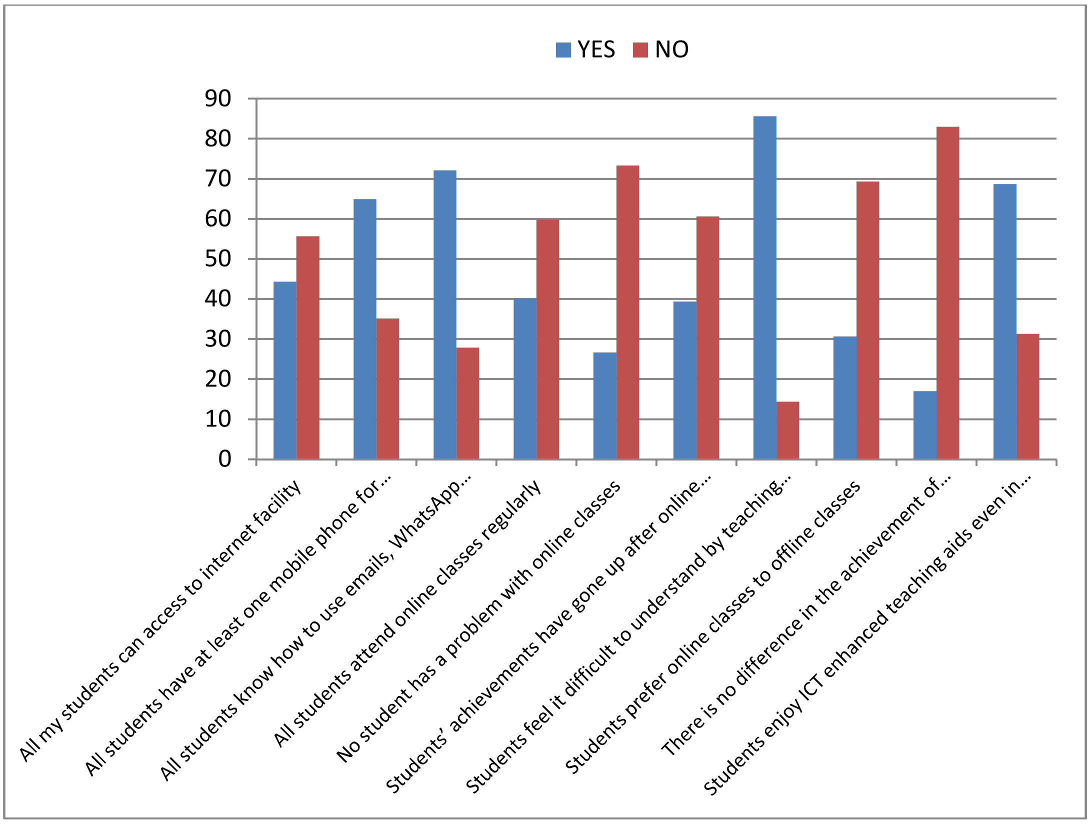


Figure 4.3: Students ability to use ICT

The following are the findings:

- A slight minority of 44.3 % of the teacher felt that all their students could access the internet, a larger section believed the opposite.
- Teachers revealed that 35.1% of their students could not access online teaching due to unavailability of at least one mobile phone at home.

- A large 72.1% of them were of the opinion that students knew how to use emails, Whatsapp and online classes.
- Only 40.2 % revealed that students attended the online classes regularly.
- A small 26.7% of them thought students did not have a problem with online classes.
- Looking at term examination results, only 39.4% of the teachers were of the idea that students achieved better with online teaching.
- A large 85.6% of them could opine that students did not respond well to information given through the internet.
- Surprisingly enough, 30.7% of the teachers still believed that students preferred online teaching to offline teaching.
- Huge majority of the teachers at 83 % indicated that online and offline teaching modes did not have much of a difference on students' performance.
- Yet, 68.7% of the teachers indicated that students enjoyed teaching through ICT.

4.11 Discussion on students' ability to use ICT

ICT has an importance only because of its role in the target group. In the present situation, there was enough evidence to clearly suggest that although ICT was enjoyed by students, as perceived by teachers, as a mode of teaching it was not a good choice as a probable choice to replace classroom teaching in the offline mode. Teachers themselves felt that less than half of the students had good internet facility. There were still 35.1% of students who did not have at least one mobile phone at home. This meant that these students had to either blindly study on their own or go to their friends who had mobile and internet when classes were carried out. It did not take deep thinking to deduce that this was the situation in most rural areas where parents are at lower economic level and internet connectivity is weak. It was of 30.7% of the teachers' opinion that students preferred online to offline classes. But the larger 69.3% of the students were clearly not in favors. Keeping in mind that nearly 35.1% of them did not have a mobile phone at home, it was natural for these groups of students to prefer offline teaching to online teaching. Since online classes were necessitated by the pandemic, it was inevitable, but it was clear that 73.3% of the students, even among the ones who had good connectivity had a problem with online classes. The students' achievement, looking at their examination marks, however, did not indicate any downward or upward change because of online classes. It was surprising; looking at their opinion in other questions, that 39.4% of them felt that students' achievement improved after online classes. And students also enjoyed ICT enhanced classes according to their own teachers. The only thing was that they did not want it to replace offline teaching. In fact, 85.6% of the mathematics teachers could see that their students did not understand mathematics through the internet. This could be due to poor connectivity or even the lack of personal touch in education through the internet.

4.12 Conclusion

It was a rewarding endeavor to undertake a study that could reveal the situation of Mizoram when it came to the effectiveness of online Mathematics teaching and learning through ICT. It was clear that technology development in the state was not at par with the needs of the situation. Moreover, disparity was seen among rural and urban schools when it came to the availability of facilities (Biswas & Rahaman, 2021). However, it was clearly seen that, even in an amenable situation, teachers themselves were not wholly convinced about the use of ICT to teach, although a small percentage of them felt that students fared better after online teaching was initiated. Teachers have varying opinions regarding their own compatibility with ICT. Some of them could even make their own e-content while others did not even own their own computer, clearly indicating that ICT training has not reached 100% of the teachers. It was felt that teachers themselves understood rather little about the many applications of ICT. Since this was the situation, it would be good if all teachers, regardless of their localities were given training in ICT along with proper incentives to induce teachers to undergo training (Mishra et al., 2020). Since ICT is going to gain importance each day, it is important that students will not face too disoriented when they come to the world of work. Students should make ready to compete with the rest of the world and bring up the state of our nation to a situation where there will be a constant flow between technology and education as visualized by the National Education Policy 2020 itself.

CHAPTER 5

EFFECTIVENESS OF ICT IN TEACHING AND LEARNING OF MATHEMATICS

5.0 Introduction

In the teaching and learning process in school, many teachers and lecturers are integrating technology into their classroom. Use of technology in teaching and learning has several advantages such as encouraging discovery learning (Bennet, 1999; Saal et al., 2019); enhancing student engagement (White, 2012) and providing greater learning opportunities for students (Roberts, 2012). In some years back, students are forced to memorize a lot of rules and theorems in order to solve mathematical problems. But during these days they can get the same results using simple computer calculations. The ICT can increase students learning process by presenting content numerically and graphically. Thus, the application of ICT in the classroom can lead to advance in conceptualization (Bhattarai, 2020). This chapter studies the effect of the use of Mathematical software for understanding mathematical problem among secondary school in Mizoram.

5.1 About ICT integration in teaching and learning

Technology can offer mechanisms to sustain assistance to mathematics teachers in their use of technology to implement mathematics education reforms in their classes (Arundhati, 2011). Technology enables mathematics education reform (Kaput, 1992; Kaput and Thompson, 1994). Mathematics educators must be provided extended opportunities to experience and do mathematics in an environment aided by diverse technologies (Dreyfus & Eisenberg, 1996; Ghavifekr & Athirah, 2015)). The core of our approach is the development of mathematical power for appreciating, using, and understanding of mathematics. Our interest is in empowering teachers through the use of technology in developing mathematics understanding, exploration, interpreting mathematics, open-ended problem solving and communicating about mathematics (Bransford, et al., 1999; Schoenfeld, 1987; Silver, 1987). In most of the country especially in a developed country, widely acknowledged that the earlier visions for how students' learning might be changed by the inclusion of technology have not translated into widespread changes in classroom practices. This is partially due to an immature knowledge of how teachers' practices are impacted by the application of new technologies, and subsequently how teachers drive in them within their professional lives, for the purpose of improving students' mathematical learning. More recent research has focused on the development of teachers' knowledge and practices within technology enhanced classroom environments. For example, the instrumental approach used in didactics of mathematics (Artigue, 2002; Trouche, 2005), initially used to analyze students' interactions with technology in mathematics learning, has been applied to the study of teachers' professional development through its central notion of "instrumental genesis", using the concept of orchestration and its extension (Drijvers et al., 2010; Trouche, 2005). During PME37 the development of teacher's practices with technology has also been discussed extensively at a Research Forum on Meta-Didactical Transposition (MDT) (Aldon et al., 2013; Arzarello et al., 2014). Other ways to describe the use and knowledge of technologies by teachers is given by theories such as Pedagogic Technological Knowledge (PTK) (Hong and Thomas, 2006; Thomas and Hong, 2005), Technological, Pedagogical and Content Knowledge (TPACK) (Koehler and Mishra, 2009; Mishra and Koehler, 2006), and the Structuring Features of Classroom Practice framework (Ruthven, 2009). A comprehensive discussion comparing TPACK, the Structuring Features of Classroom Practice Framework and the Instrumental Orchestration Approach can be found (Ruthven, 2014). Further to this, research on teacher identities has also contributed insights into how and why teachers develop their practice (or not) as users of technology-based learning. From a socio-cultural perspective, teachers' learning is conceptualized as the evolution of their participation in practices that develop their pedagogical identities, which Wenger (1998) describes as "a way of talking about how learning changes who we are". As this Research Forum is focused on making visible the dynamic processes of teachers' development of their classroom practices with and through technology over time, the theoretical frameworks have been chosen as they enable this temporal element to be seen. However, our choices are not exhaustive!

5.2 Methodology

The methodology used in this chapter is to form online module for students of secondary level and teach their current mathematics syllabus using Teachmint, Microsoft Office, Smartdraw and free mathematical software Geogebra, and finally students' response was analyze using statistical tools to predict the effectiveness of the module for teaching and learning mathematics.

5.3 Problems selected for the module

The following are some of the problems discuss in the module.

5.3.1 Construction of tangents to a circle from a point outside it

Steps of Construction

1. Draw a circle with Centre O and a given radius by choosing circle Centre and radius

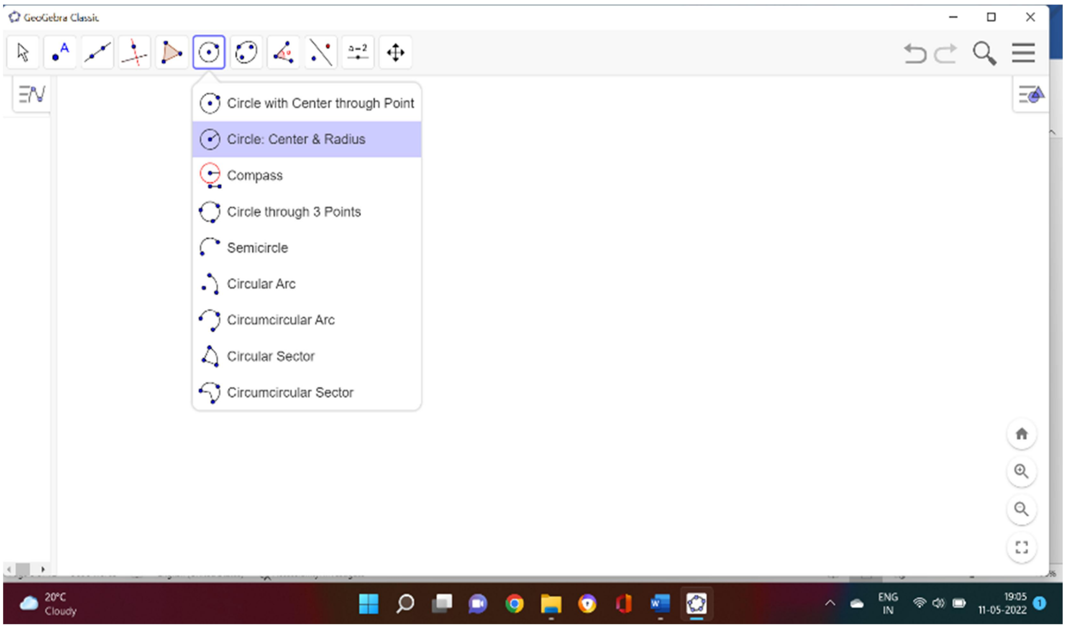


Figure 5.1 : Geogebra page

2. Draw a right bisector of OP (Where P is a given point outside a circle), intersecting OP at M.

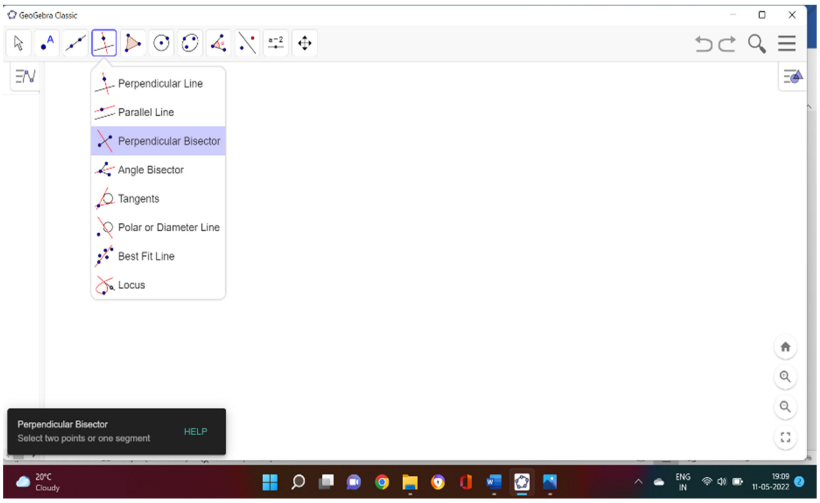


Figure 5.2 : Geogebra page

3. Taking M as a Centre and radius MO or MP, draw a circle which intersects the given circle at points T and T'.

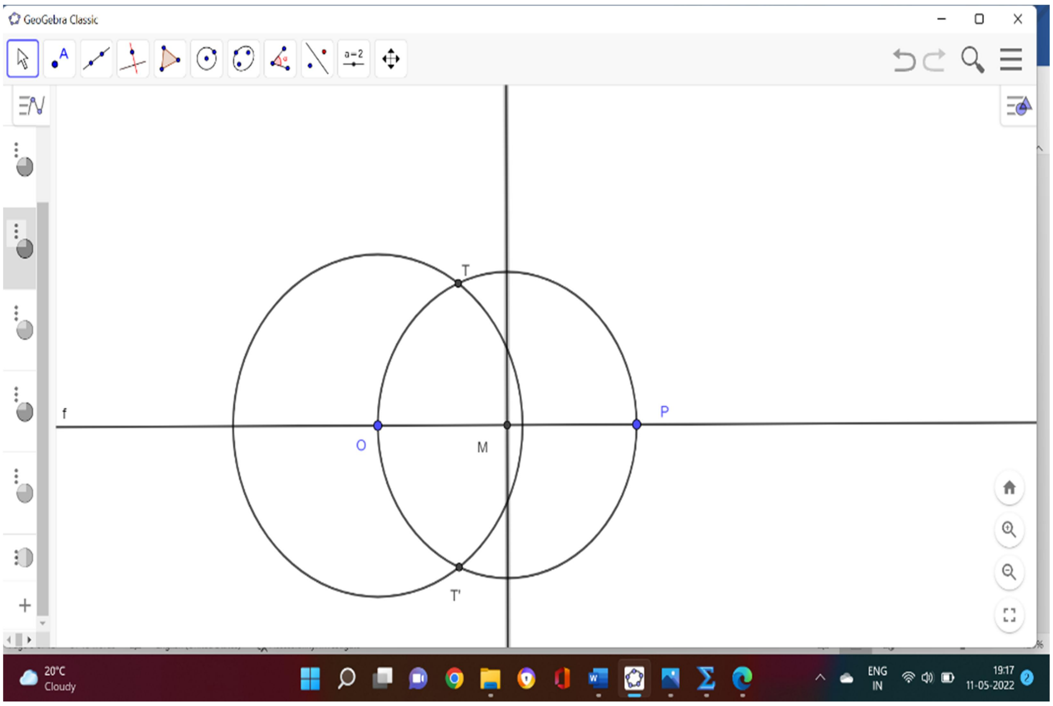


Figure 5.3: Geogebra page of drawing

4. Join PT and PT' to get the required tangents

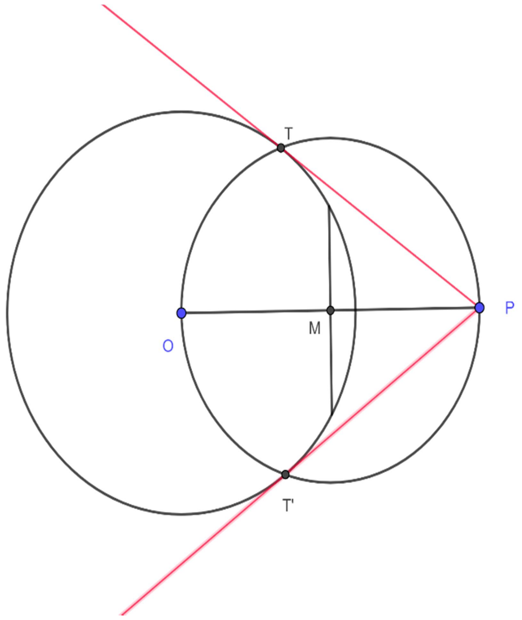


Figure 5.4: Two tangents of a circle from a point outside it

5.3.2 <u>Solving Linear Equation:</u>

Mr A went to a fair in a city. He wants to enjoy rides on the merry Go Round and play the shooting game. The number of times he shot is double the number of rides he had on a merry Go round. If each ride costs Rs 10, and a shot costs Rs 2, how can we find out the number of rides he had and how many times he shot, provided he spent Rs 70.

Solution: Denote the number rides that Mr A had by x and the number of times he shot by y. Then the two linear equations are given below:

$$y = 2x$$
$$and \quad 10x + 2y = 70$$

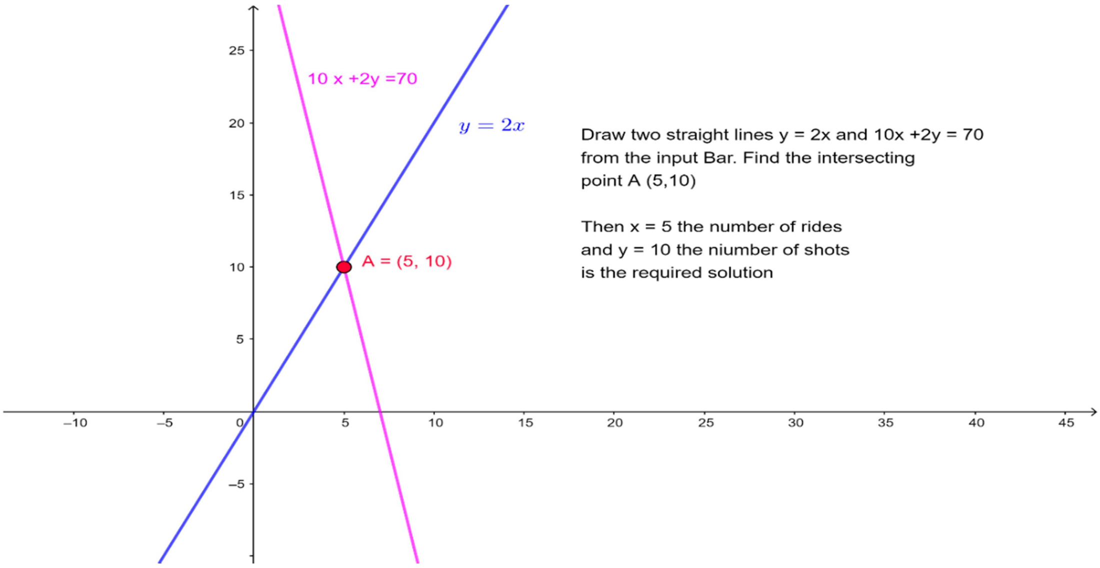


Figure 5.5: Graphical solution of simultaneous linear equation

5.3.3 Solving Quadratic Equation:

A village decided to build a park having an area of 25000 m^2 with its length 50 meters more than twice its breadth. What should be the dimension of the park?

Solution: Let the breadth of the park be x meters. Then its length should be ($2x$+50) meters. Thus

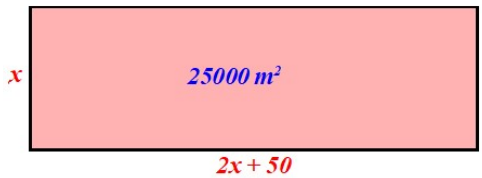


Figure 5.6: Rectangular Park

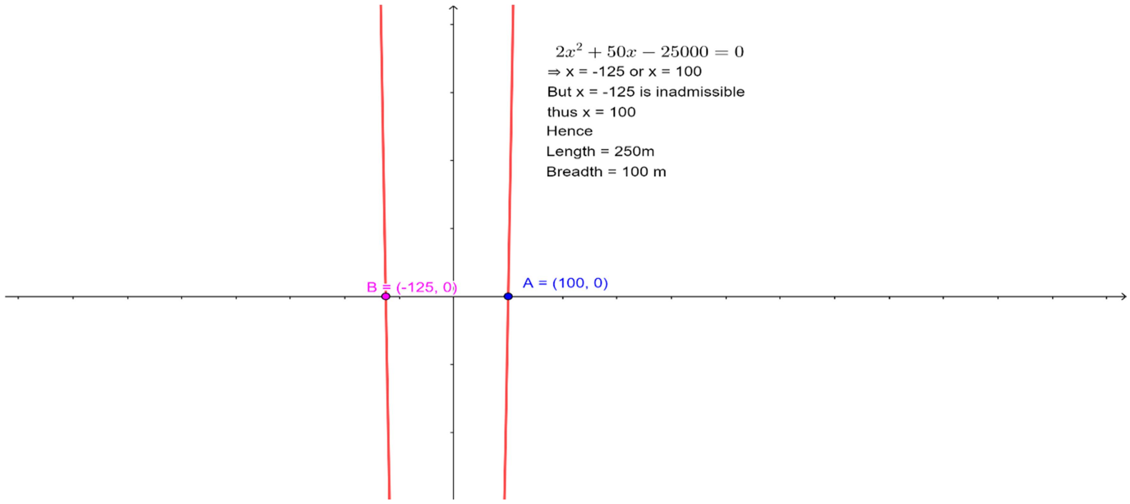


Figure 5.7: Graph of quadratic equation.

5.3.4 Coordinate Geometry : Distance formula

Find the distance between the Pairs of points (2, 3) and (4, 1) ?

Solution: Let the two points be P (2, 3) and Q (4, 1)

We need to find $PQ = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$.

Check the figure carefully

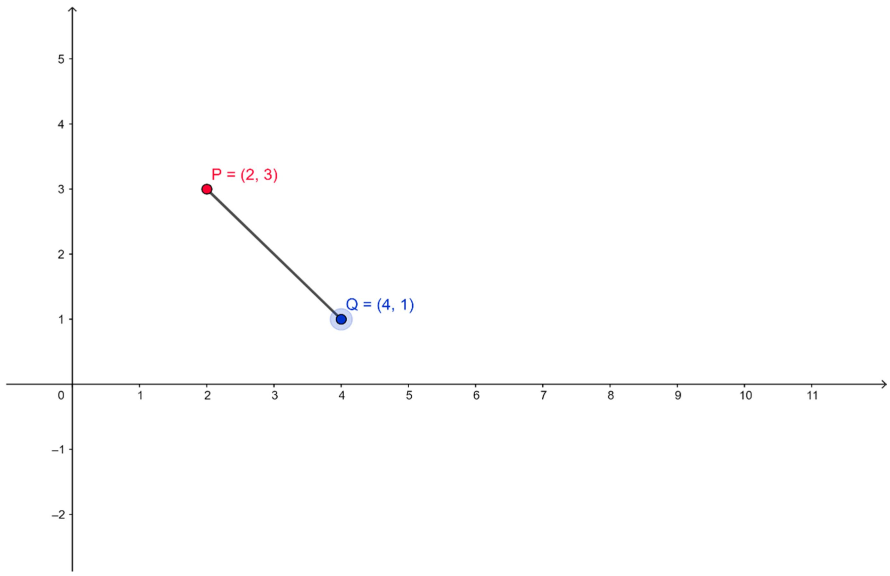


Figure 5.8: Distance between two points

Now we have,

$$x_1 = x \text{ coordinate of } P = 2$$
$$y_1 = y \text{ coordinate of } P = 3$$
$$x_2 = x \text{ coordinate of } Q = 4$$
$$y_2 = y \text{ coordinate of } Q = 1$$

Putting those value, we get

$$PQ = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$
$$= \sqrt{(4-2)^2 + (1-3)^2}$$
$$= \sqrt{2^2 + (-2)^2}$$
$$= \sqrt{8}$$
$$= 2\sqrt{2}$$

Hence the distance between P and Q is $2\sqrt{2}$ unit.

5.3.5 Section formula

If a line segment AB is divided by the point P in the ratio hi 2:3. Let the coordinate of A and B coordinate be A(1,2) and B(6,7)). Find the coordinate of P.

Solution: Let the coordinate of P be P(x,y). Check the figure given below you can easily notice that P divide AB such that AP = 2 and PB = 3. Our aim is to find out the coordinate of P using section formula.

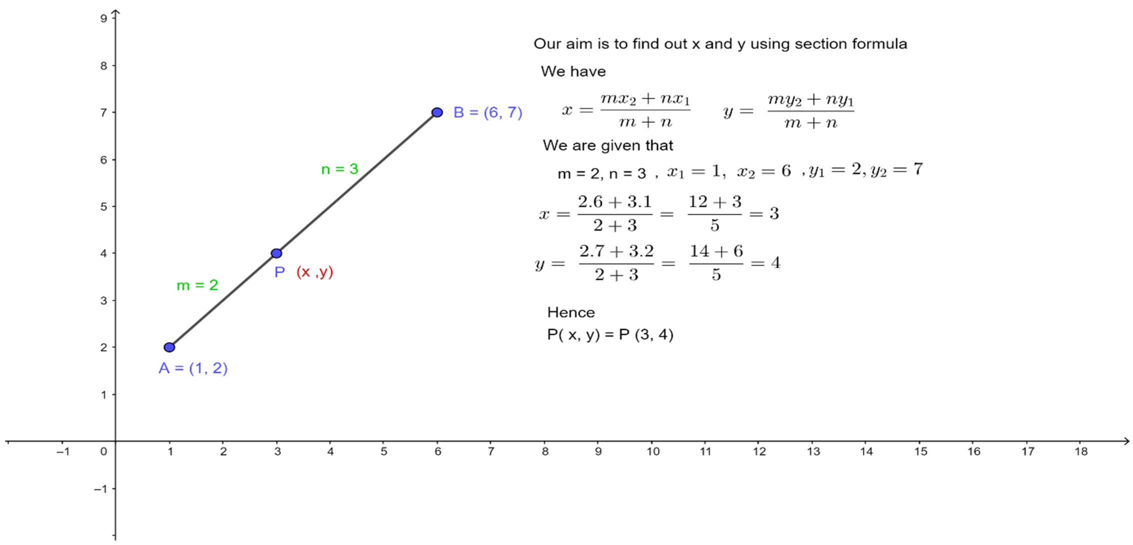


Figure 5.9: Internal division

5.3.6 Area of a Triangle

Find the area of a triangle whose vertex are A(1,1), B(6,2) and C(2,4).

Solution: We know that

If the vertex of a triangle be $A(x_1, y_1), B(x_2, y_2)$ and $C(x_3, y_3)$, then

$$\text{Area } \Delta ABC = \frac{1}{2}[x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)]$$

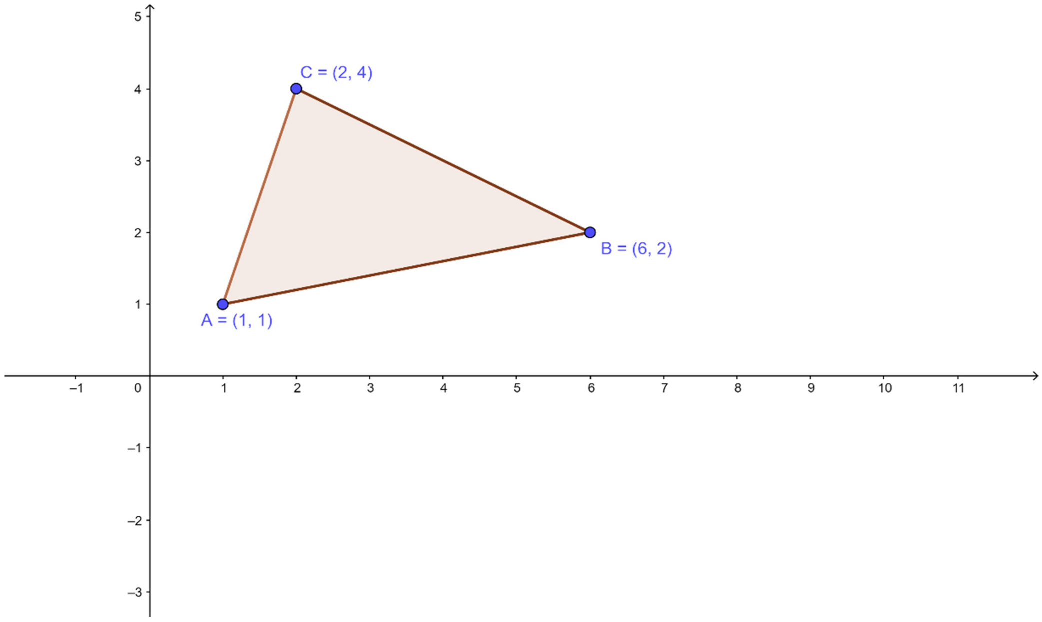


Figure 5.10: Triangular area

From figure we have

$$x_1 = 1,\ x_2 = 6,\ x_3 = 2 \text{ leh } y_1 = 1,\ y_2 = 2,\ y_3 = 4,\ then$$

$$\begin{aligned}\text{Area } \Delta ABC &= \frac{1}{2}[x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)] \\ &= \frac{1}{2}[1(2-4) + 6(4-1) + 2(1-2)] \\ &= \frac{1}{2}[-2 + 18 - 2] \\ &= \frac{14}{2} \\ &= 7 \quad Sq.unit\end{aligned}$$

Hence the area of the given triangle is 7 sq. unit

5.3.7 Theorem of Thales: The angle in a semi-circle is at right angle.

The classical Solution:

Given: AB is a diameter of a circle C (O, r) and $\angle ACB$ is an angle in a semicircle.

To Prove: $\angle ACB = 90^{\circ}$

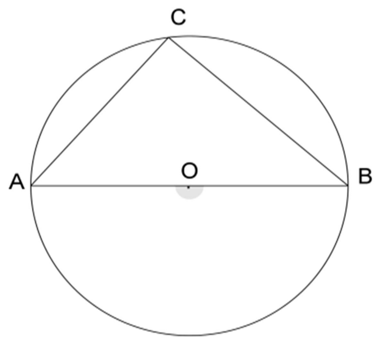


Figure 5.11: Angle in a semi-circle

Proof: We know that the angle subtended by an arc at the centre of a circle is twice the angle form by it at any point on the remaining part of the circle.

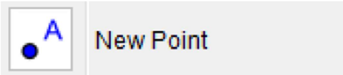
$$\therefore\ \angle AOB = 2\angle ACB$$
$$\Rightarrow 2\angle ACB = \angle AOB = 180^{\circ} [\because\ \angle AOB \text{ is a straight angle}]$$
$$\Rightarrow \angle ACB = 90^{\circ}$$

Solution (GeoGebra):

1. Draw segment AB by selecting segment between two point tool

2. Construct a semicircle through points A and B
   <u>Hint</u>: The order of clicking points A and B determines the direction of the semicircle.

3. Create a new point C on the semicircle
   <u>Hint</u>: Check if point C really lies on the arc by dragging it with the mouse.



4. Create triangle ABC

5. Create the interior angles of triangle ABC

6. Move the point C along the circumference and we get the GeoGebra figure below:

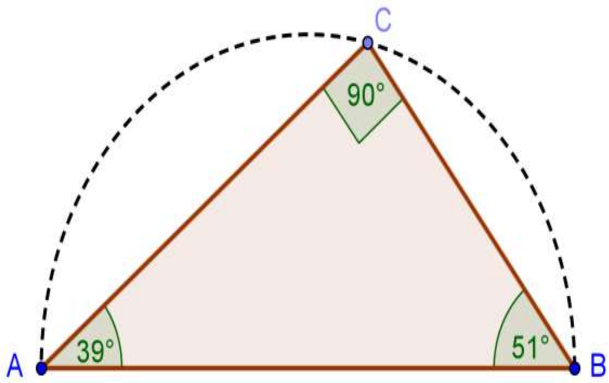
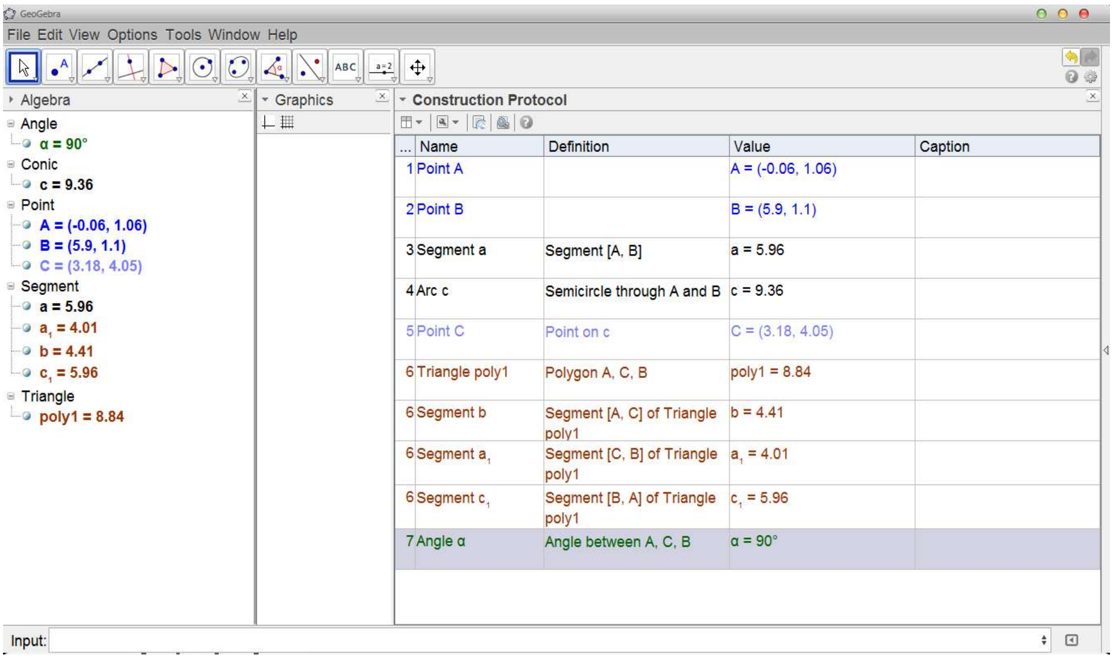


Figure 5.12: Angle in a semi-circle using Geogebra



...	Name	Definition	Value	Caption
1	Point A		A = (-0.06, 1.06)	
2	Point B		B = (5.9, 1.1)	
3	Segment a	Segment [A, B]	a = 5.96	
4	Arc c	Semicircle through A and B	c = 9.36	
5	Point C	Point on c	C = (3.18, 4.05)	
6	Triangle poly1	Polygon A, C, B	poly1 = 8.84	
6	Segment b	Segment [A, C] of Triangle poly1	b = 4.41	
6	Segment a_1	Segment [C, B] of Triangle poly1	a_1 = 4.01	
6	Segment c_1	Segment [B, A] of Triangle poly1	c_1 = 5.96	
7	Angle α	Angle between A, C, B	α = 90°	

Table 5.1: Step of construction

Discussion:

Figure 2 shows a dynamic worksheet that allows students to explore the theorem of Thales. Vertex C of the triangle ABC lies on a semicircle over segment AB. Following the instructions above the dynamic figure, students are guided towards discovering the meaning of this theorem, stating that such a triangle is always a right triangle. After coming up with a conjecture, students can verify it for a number of different triangles, which can be created by moving points A and B with the mouse to another position. From the GeoGebra figure above one can easily identify the angle in a semi-circle is at right angle. If we move the point C by selecting move or drag tools it can be found that there is no change in the magnitude of the angle C which is more attractive for student to agree the theorem. The following tables below are the construction protocol and through it one can have complete necessary information.

5.3.8 Pythagorean Theorem:

Let '*a*' and '*b*' be the lengths of sides of a right triangle, and let '*c*' be the length of the hypotenuse. Then the sum of the areas of the squares on '*a'* and *'b'* equal to the area of the sum of the square on '*c'*.

<u>Prove of Pythagorean Theorem (GeoGebra)</u>

To Prove: The sum of the areas of the squares on two sides equal to the area of the sum of the square on the hypotenuse.

1) Start the new sketch and hide the axis.
2) Select segment between two-point tool and draw a line segment AB.
3) Select semi-circle through two-point tool and draw a semicircle through the line segment.
4) Choose any point on the circle called as C.
5) Select segment between two-point tool, joint AC and BC.
6) Select the angle tool find angle C.
7) Hide the semi-circle

8) Select the distance tool and click all the line.

9) Select regular polygon tool and draw a square from all the sides.

10) Select area tool and find the area of a squares.

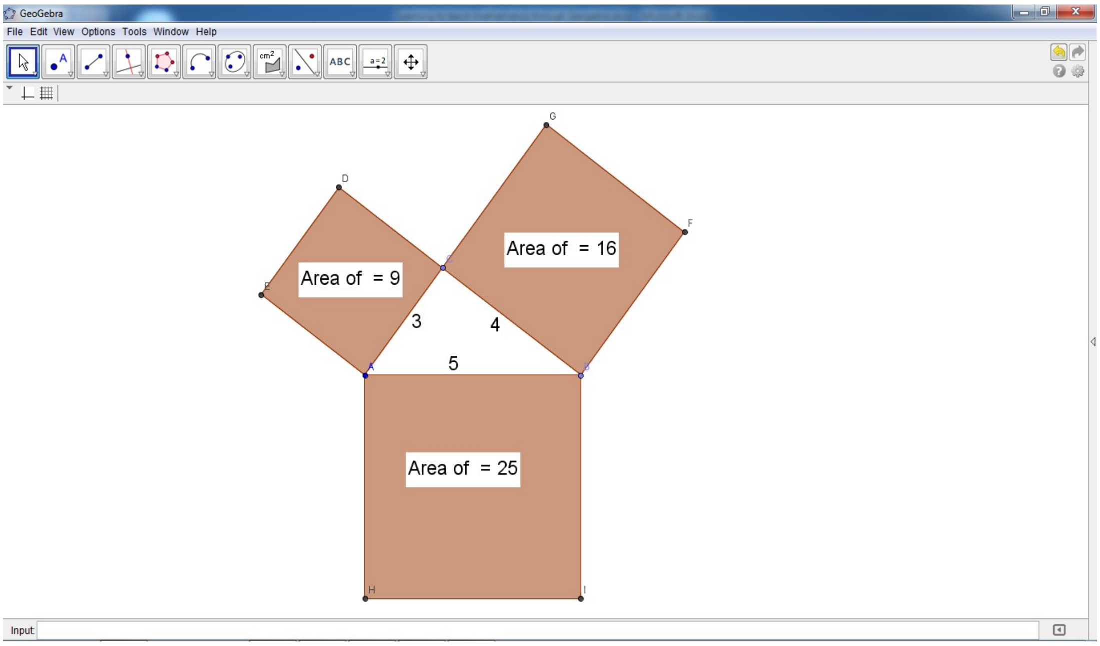


Figure 5.13: Prove of Pythagorean theorem using Geogebra.

Discussion:

There are over 10 proofs of Pythagoras's theorem with GeoGebra inter activities. The goal of each inter activity is to show the different types of thinking and reasoning in a colourful dynamic way. Pythagoras lived in the 500's BC, and was one of the first Greek mathematical thinkers. Pythagoreans were interested in Philosophy, especially in Music and Mathematics. The statement of the Theorem was discovered on a Babylonian tablet circa 1900– 1600 B.C. Professor R. Smullyan in his book 5000 B.C. and Other Philosophical Fantasies tells of an experiment he ran in one of his geometry classes. He drew a right triangle on the board with squares on the hypotenuse and legs and observed the fact that the square on the hypotenuse had a larger area than either of the other two squares. Then he asked, "Suppose these three squares were made of beaten gold, and you were offered either the one large square or the two small squares. Which would you choose?" Interestingly enough, about half the class opted for the one large square and half for the two small squares. Both groups were equally amazed when told that it would make no difference. Like this example we can consider some real-life applications to Pythagorean Theorem: The Pythagorean Theorem is a starting place for trigonometry, which leads to methods, for example, for calculating length of a lake, Height of a Building and length of a bridge etc.

It is important for students to understand and know basic geometric proofs. Of course, knowing more complicated proofs is also important. However, too many times mathematics teachers are not able to recall this situation of basic geometrical proof. The proof itself is not complicated, but the additional information is necessary to broaden understanding and help trigger recall. In order to answer the fundamental postulate, the teacher should be aware of the possible correlated mathematics. Students must be aware of the theorem about parallel lines and transversal. Teacher should be able to clarify the student's misconceptions and confusions with the summation of the measures of interior triangular angles. So why do we as teachers need to know this property of triangles? The bottom line is triangles are a fundamental shape in geometry. Any polygonal shape can be triangulated, i.e. the polygonal shape can be broken down into a set of triangles. Triangulation breaks down complex shapes into a set of simple shapes thus theorems involving triangles can be used to prove conjectures about complex shapes. In addition, without triangles we would not have Trigonometry. Triangles are a staple to geometry and mathematics as a whole. Without triangles our explorations and knowledge of mathematics would be limited.

5.4 Statistical Analysis of Students' Perception on ICT integrated Mathematics Classroom

5.4.1 Objectives of the Study

The objective of this study is to delve into the student's perception relating to the implementation and output of ICT integration in mathematics classroom. In addition, this study aimed to establish the students' perception relating to implementation of GeoGebra software in Mathematics Classroom.

5.4.2 Hypothesis of the Study

The following hypotheses were formulated in this study:

1. **H_0**: There is a negative perception of students relating to the implementation and output of ICT integration in mathematics classroom.

   H_1: There is a positive perception of students relating to the implementation and output of ICT integration in mathematics classroom.

2. **H_0**: There is a negative perception of students relating to the implementation of GeoGebra software in Mathematics Classroom.

   H_1: There is a positive perception of students relating to the implementation of GeoGebra software in Mathematics Classroom.

5.4.3 Population Sample and Sampling Technique

The overall total of respondents for this research was 385 students from three different Secondary Schools within Aizawl District viz. Government Chaltlang Higher Secondary School, Government Mizo Higher Secondary School and Government Zemabawk Higher Secondary School, in the academic year 2021-2022.

The perception of students relating to ICT integration in their mathematics classroom was collected on the basis of questionnaire prepared by the researcher. A five points Likert response was employed with a scale of Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree and analyzed the collected data by using weighted mean, percentage and Chi-square test at 0.05 level of significance was used to test the formulated hypotheses in this study.

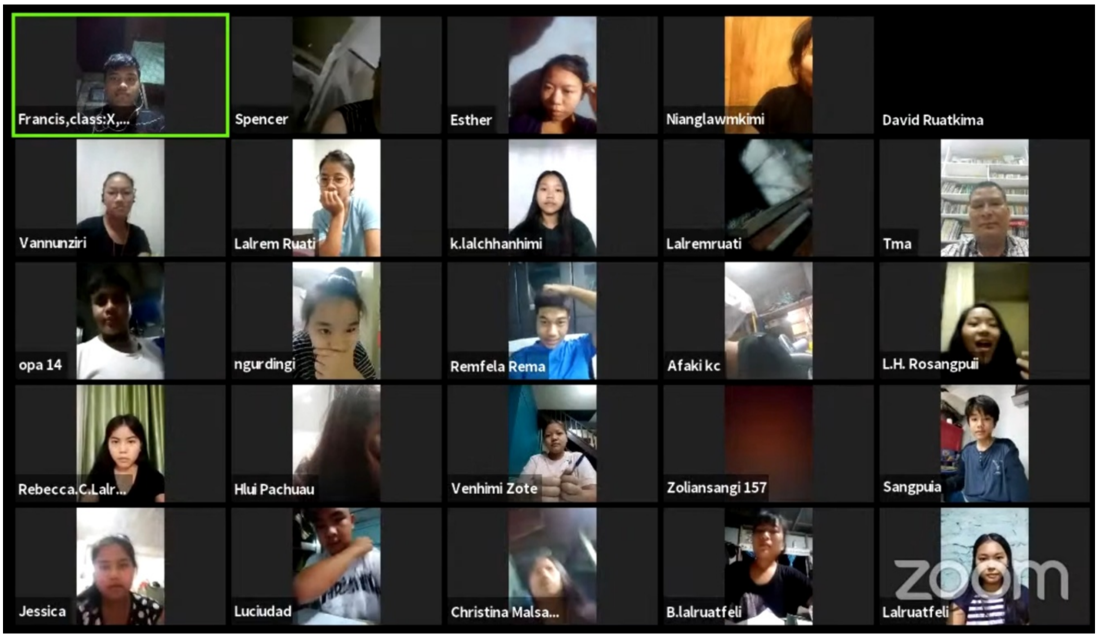


Figure 5.14: Training on ICT for Secondary students using ZOOM online

5.5 Results and Discussion

The data in this study was collected through a questionnaire with students relating to the implementation and output of ICT integration in mathematics classroom. Therefore, in this section, I present the detail of the data in the form of results and discussion as mentioned in the following tables.

Table 5.2: Students' perceptions relating to ICT integration in Mathematics Classroom

Ques-tions	Statements	SA	A	U	DA	SDA	Weighted Mean	Remarks
1	I am comfortable using technology in foreign language classroom	19	256	64	41	5	3.63	P
2	I think that ICT allows me to learn more in the time I have for studies	23	231	82	43	6	3.58	P
3	I think that ICT improves my learning	28	220	90	39	8	3.57	P
4	I feel confident learning new computer skills	42	217	77	41	8	3.63	P
5	I find it easier to learn by using ICT	27	194	110	46	8	3.48	P
6	I am aware of the great opportunities that ICT offers for effective learning.	16	231	106	26	6	3.58	P
7	I think that ICT supported learning more interesting	37	249	62	31	6	3.73	P
8	Pay less attention when ICT is use for learning	16	125	106	115	23	2.99	NP
9	No effort to make if ICT is used in learning	10	102	160	95	18	2.98	NP
10	It is important to have course contents appropriately structured based on the objectives of the course.	15	276	80	10	4	3.75	P
11	Providing useful learning materials associated with math education is important	63	276	29	11	6	3.98	P
12	Clear guidelines on course assignment and assignment rubrics are important	40	266	59	16	4	3.84	P
13	Assignment examples are important	82	256	30	11	6	4.03	P

14	Having the quiz available online is important	41	234	76	27	7	3.71	P
15	Using a discussion board is important	49	251	65	15	5	3.84	P
	Average	**6.77**	**56.4**	**26.57**	**18.9**	**8**	$\chi^2 = 904.25$	H_o **Reject**

(SA: Strongly Agree, A: Agree, U: Undecided, DA: Disagree, SDA: Strongly Disagree, P: Positive perception, NP: Negative Perception)

Table 5.2 shows that the students' perception on ICT integration in Mathematics classroom.

Figure 5.15, (i) – (xv): Bar graph representation of table 5.2

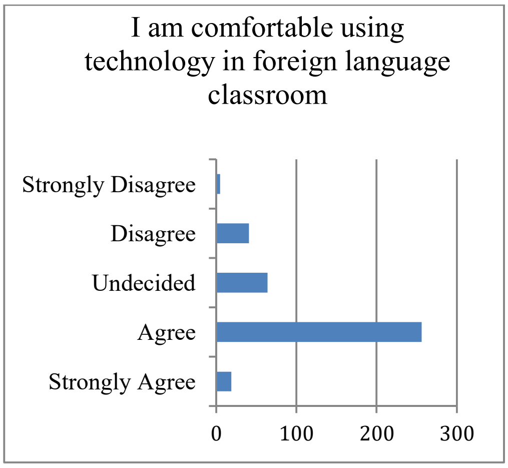


Figure 5.15 (i)

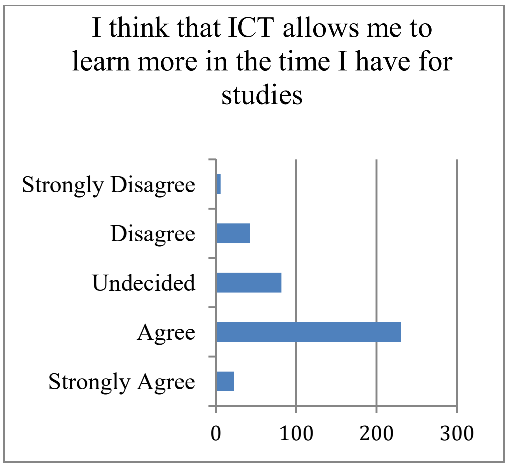


Figure 5.15 (ii)

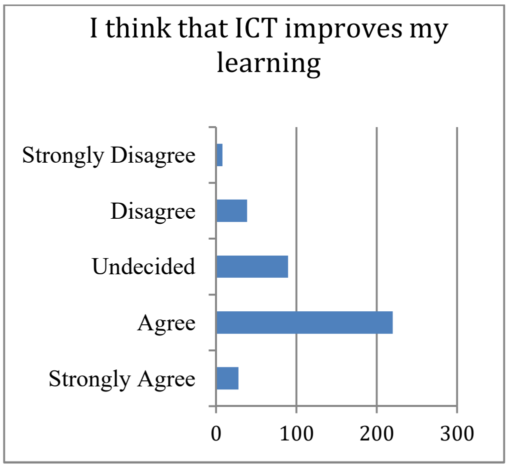


Figure 5.15 (iii)

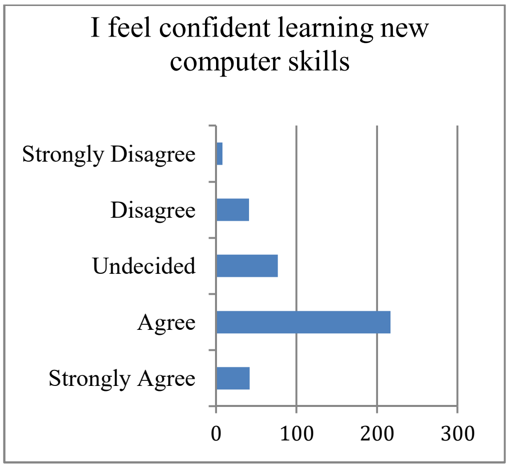


Figure 5.15 (iv)

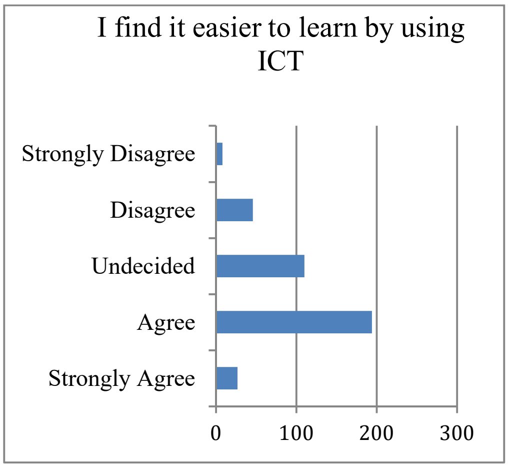
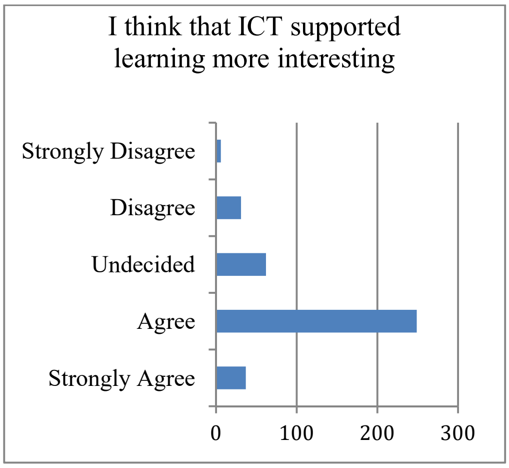


Figure 5.15 (v)

Figure 5.15 (vi)



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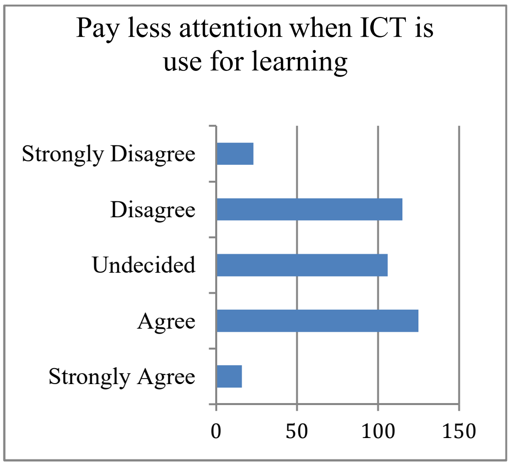

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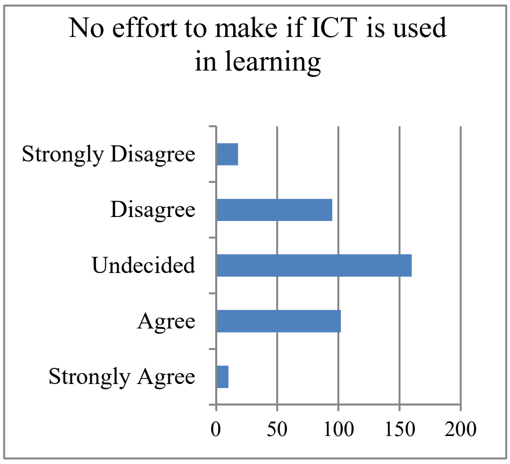

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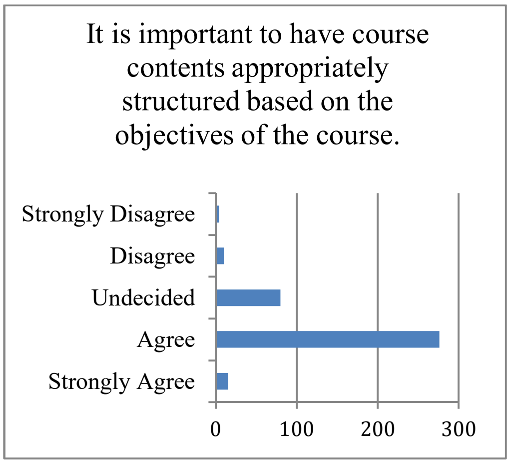

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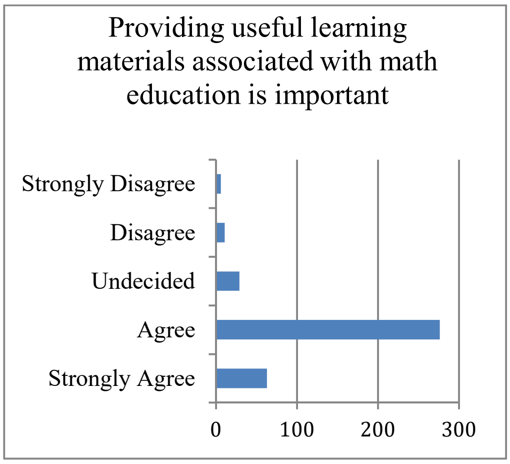

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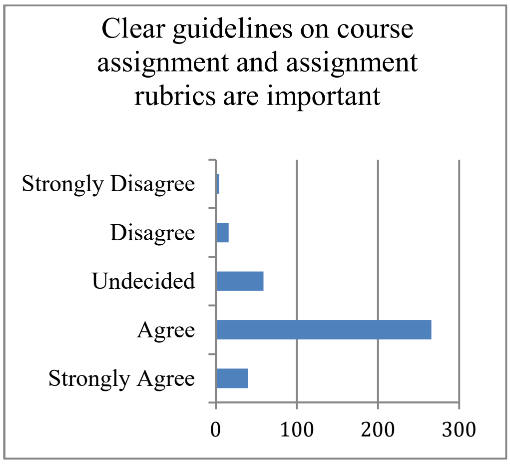

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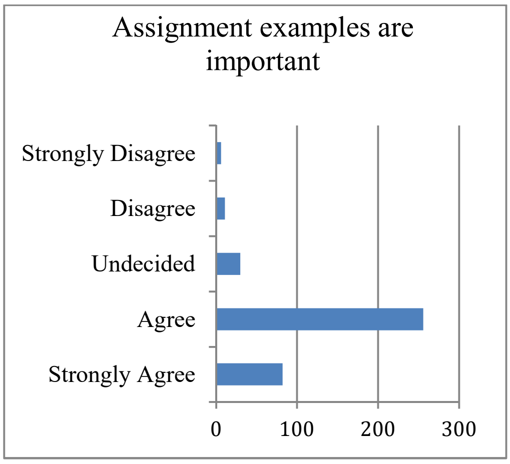

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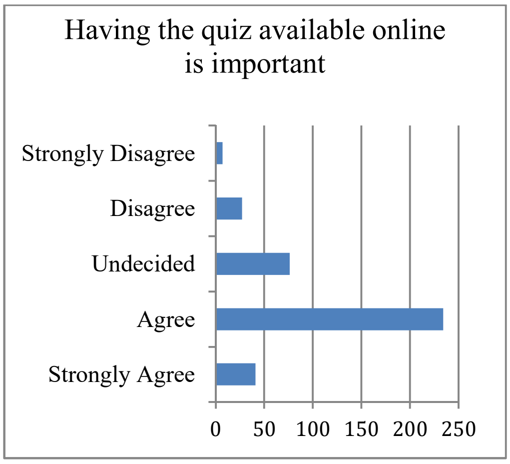

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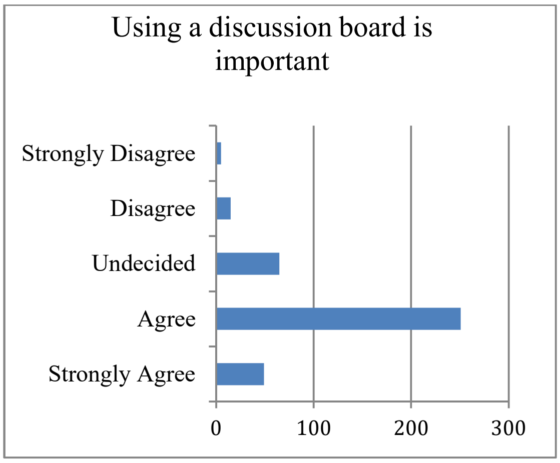

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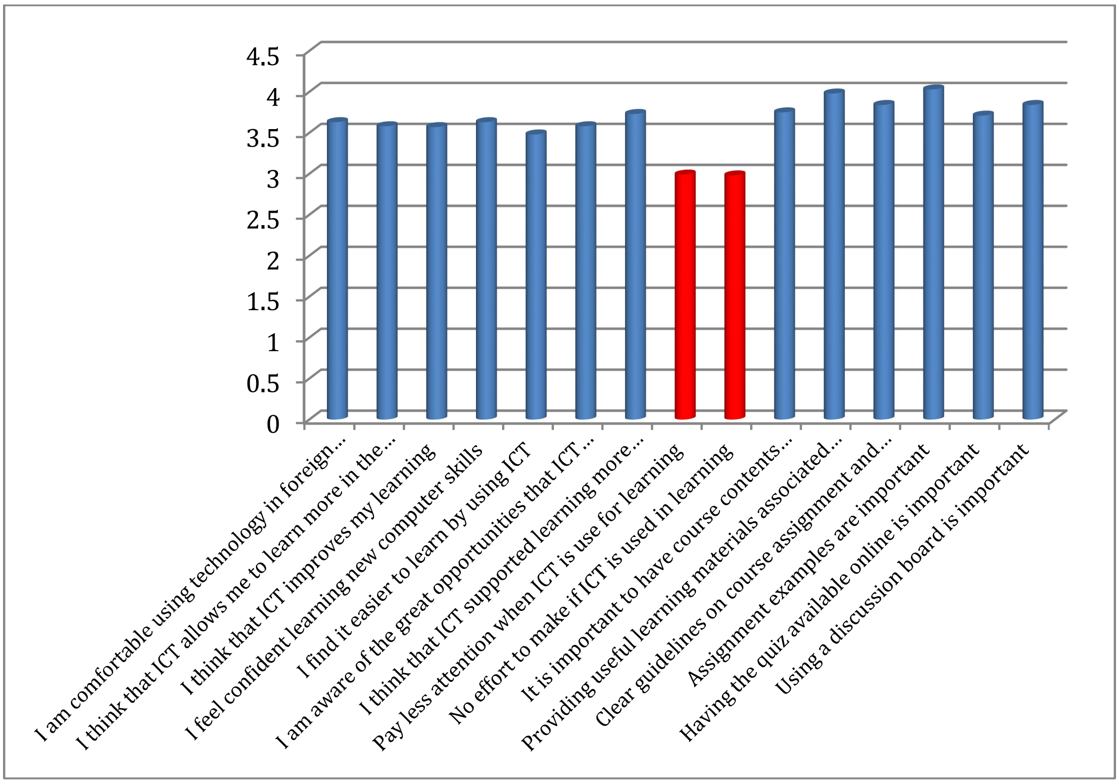


Figure 5.16: Weighted Mean for Students' perceptions relating to ICT integration in Mathematics Classroom

As reflected in table 5.2 and figure 5.14, the weighted mean of twelve statements were found greater than three and only two statements were less than three. Also, the calculated value of χ^2 = 904.25 is much greater than the tabulated value 74.47 at a 0.05 level of significance. So the null hypothesis is rejected and this implies that the Secondary students have a positive perception towards ICT integration in Mathematics classroom. Besides these, the students reflected that the ICT integration has a positive impact to increase their confidence level and found more interesting while learning Mathematics.

More than 86.67% of the respondents agreed on the effective use of ICT integration in mathematics classroom and it can help students' critical thinking to solve a mathematical problem. The reflection of students also indicated that the ICT integration would contribute to increasing necessary competencies on students as compared to the traditional approach. However, 13.33% of the respondents' revealed that they pay less attention and no effort was made if ICT is used in learning Mathematics, which were less in number compared to the overall secondary students surveyed in this study.

Table 5.3: Students' perceptions relating to output of ICT integration in Mathematics Classroom

Questions	Statements	SA	A	U	DA	SDA	Weighted Mean	Remarks
1	I think that getting information from ICT is better than using printed materials/text books.	192	96	97	0	0	4.25	P
2	I think that the use of ICT allows me to take greater control of my language learning	233	55	84	5	8	4.30	P
3	I use ICT to create my own digital learning resources (Web-pages, blogs, mind maps, etc)	175	99	110	1	0	4.16	P
4	I use ICT to communicate with international peers on topics of personal interest.	178	82	123	0	2	4.13	P
5	I use ICT to communicate with international peers on education related matters	197	74	110	3	1	4.20	P
6	ICT (e.g. the Internet) permits access to current learning materials	257	41	85	2	0	4.44	P
7	I would like to use ICT more in language learning	245	76	61	0	3	4.45	P

8	The use of ICT helps students to improve learning with more updated materials.	253	48	77	7	0	4.42	P
9	The use of ICT enables the students to be more active and engaging in the lesson	216	61	108	0	0	4.28	P
10	I think the use of ICT in learning is a waste of time.	66	74	108	77	60	3.02	NP
	Average	**40.22**	**20.45**	**32.82**	**1.00**	**1.64**	$\chi^2 = 1184.70$	H_o **Reject**

(SA: Strongly Agree, A: Agree, U: Undecided, DA: Disagree, SDA: Strongly Disagree, P: Positive perception, NP: Negative Perception)

Figure 5.17, (i) to (x): Bar graph representation of Table 5.3

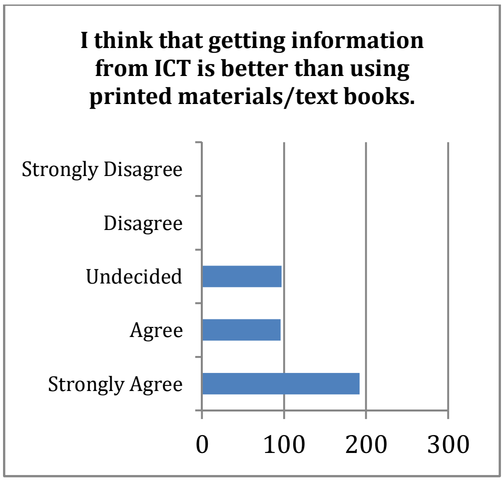


Figure 5.17 (i)

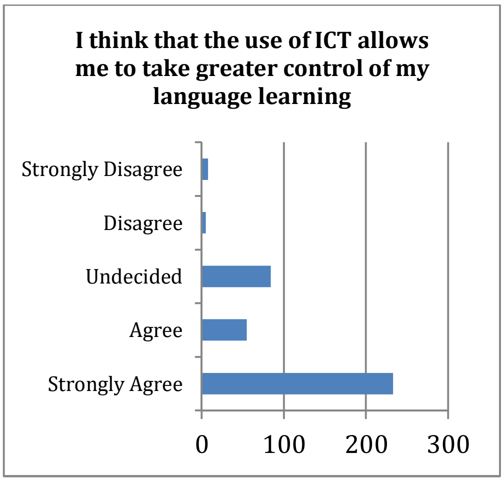
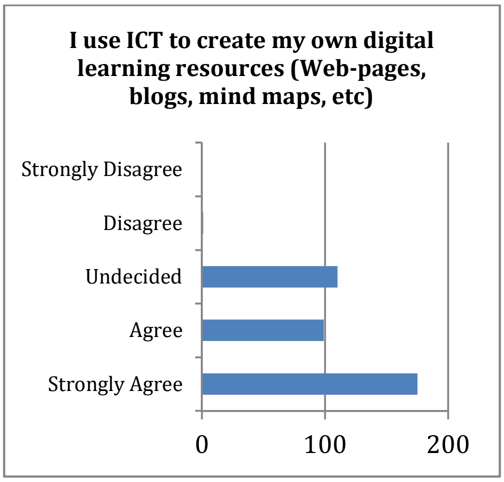


Figure 5.17 (ii)



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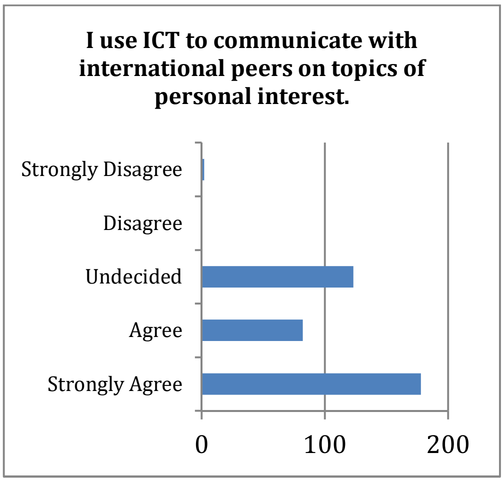

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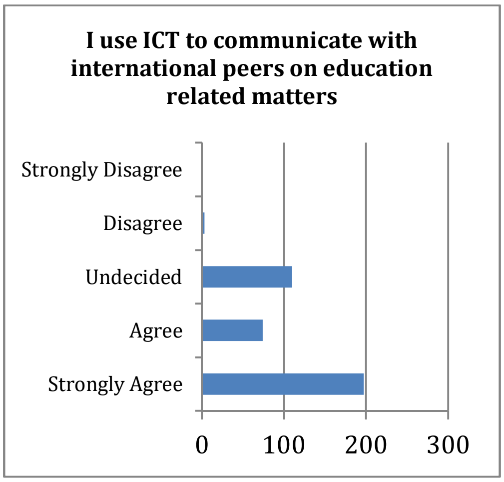

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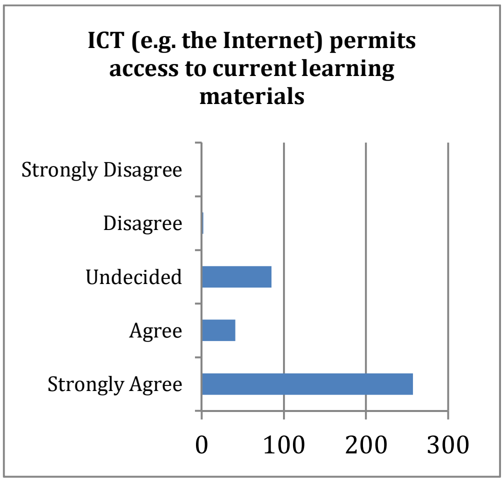

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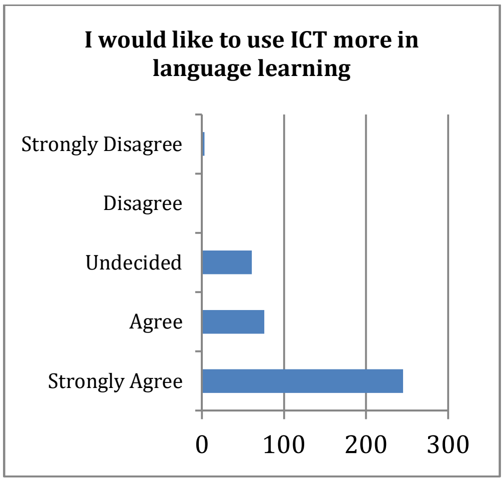

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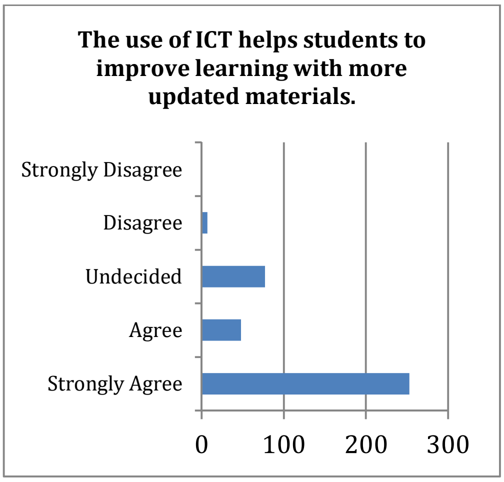


Figure 5.17 (viii)

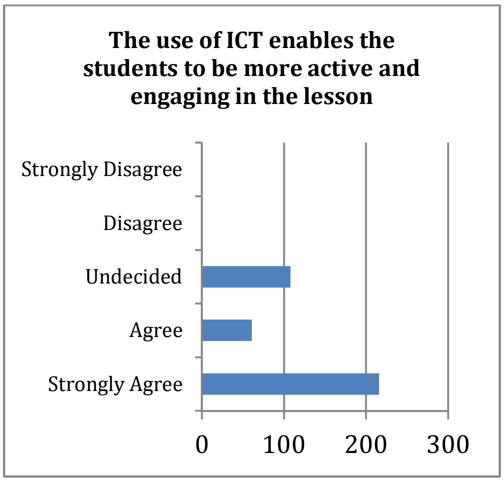


Figure 5.17 (ix)

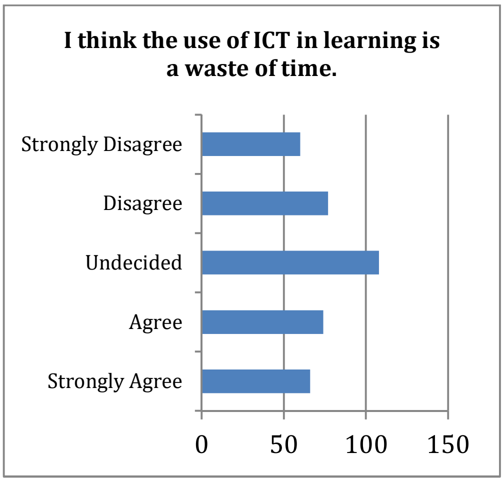


Figure 5.17 (x)

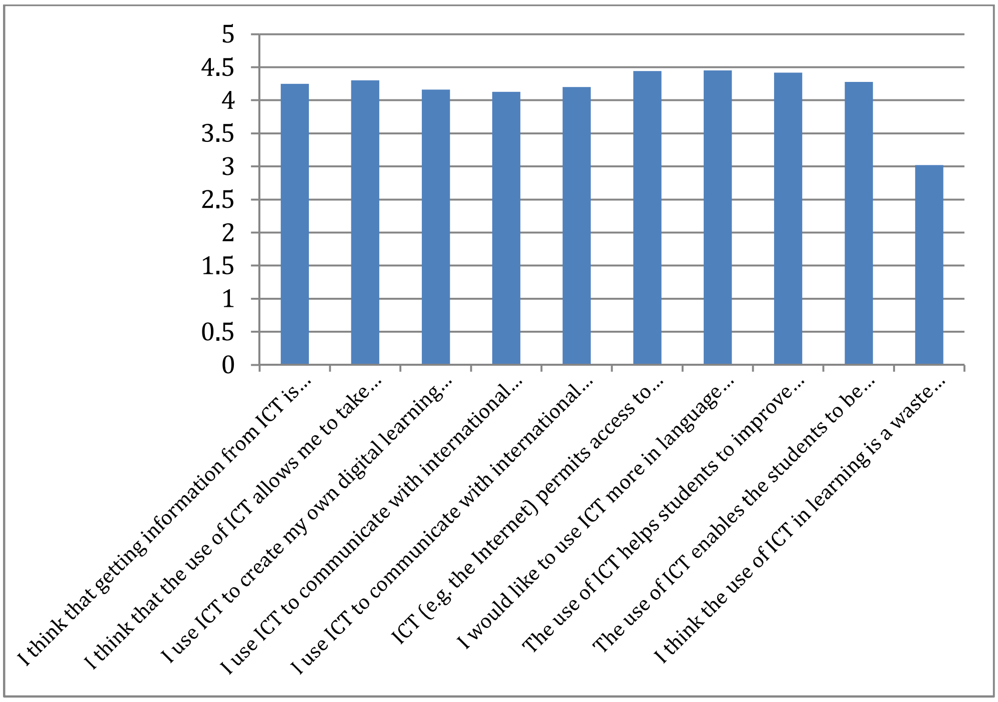


Figure 5.18: Weighted Mean of Students' perceptions relating to output of ICT integration in Mathematics Classroom

From the above table, it is found that the weighted mean of the nine statements was found to be greater than 3.39 with the average weighted mean of 4.29. This implies that the students rated the use of ITC integration in Mathematics learning as effective.

In addition, the calculated value of χ^2=1184.70 is greater than the tabulated value of 55.76 at a 0.05 level of significance. So the null hypothesis is rejected and found that secondary students have a positive perception of the output of ICT integration in Mathematics learning. Moreover, 90% of the respondents agreed on the effective use of ICT integration in mathematics classroom and the use of ICT helps them to improve learning with more updated materials. The reflection of students also indicated that the ICT integration would enabled them to be more active and engaging in the lesson. However, 10% of the respondents' brought out that the use of ICT in learning is a waste of time if ICT is used in learning Mathematics, which were less in number compare to the overall secondary students in this study.

Table 5.4: Students' perceptions relating to implementation of GeoGebra software in Mathematics Classroom.

Questions	Statements	SA	A	U	DA	SDA	Weighted Mean	Remarks
1	I got clear concept while teacher used GeoGebra in teaching mathematics.	18	344	3	19	1	3.93	p
2	I feel GeoGebra is essential and important software for teaching mathematics.	22	338	4	19	2	3.93	p
3	GeoGebra mostly encourage me and my friends to take path and improve mathematics performances.	23	337	5	19	1	3.94	p
4	GeoGebra software made me more clearly about any figure that visualize through teacher in mensuration.	19	344	4	17	1	3.94	p

5	The use of GeoGebra software in mensuration chapter ensures long time memorization of what the teacher taught.	22	341	4	18	0	3.91	p
6	The GeoGebra software gives as very clear concept about mensuration connecting on real life problems.	16	346	5	17	1	3.93	p
7	The software gives us meaningful information on subject matter.	28	332	5	19	1	3.95	p
8	I will explain about GeoGebra software to all who have curiosity.	20	344	3	18	0	3.95	p
9	Mathematical software help me to understand the usefulness of mathematics	56	306	4	14	5	4.02	p
10	The course gave me to understand the concept of school mathematics	38	320	5	15	7	3.95	p
11	The short-term training course gave me a great challenge	47	313	5	16	4	3.99	p
12	I feel a lot more confident about doing Mathematics now than I did before the course	52	310	5	11	7	4.01	p
	Average	**6.02**	**82.81**	**1.44**	**8.42**	**2.50**	$\chi^2 = 4830.50$	H_o **Reject**

Table 5.4 showed that the students' perceptions relating to implementation of GeoGebra software in Mathematics Classroom. It can represent table 5.4 in Bar graph as shown in Figure 5.19 (i to xii) below.

Figure 5.19 (i) to (xii): Bar graph representation of table 5.4.

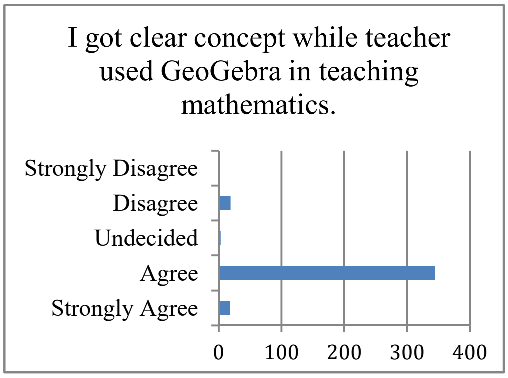


Figure 5.19 (i)

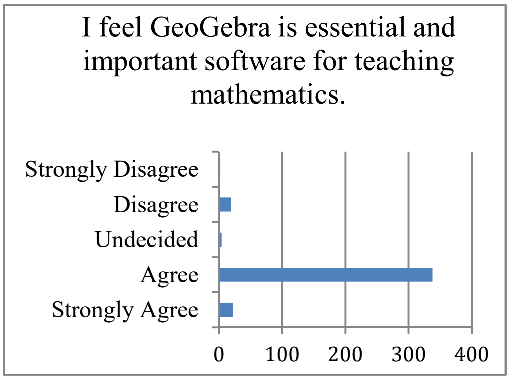


Figure 5.19 (ii)

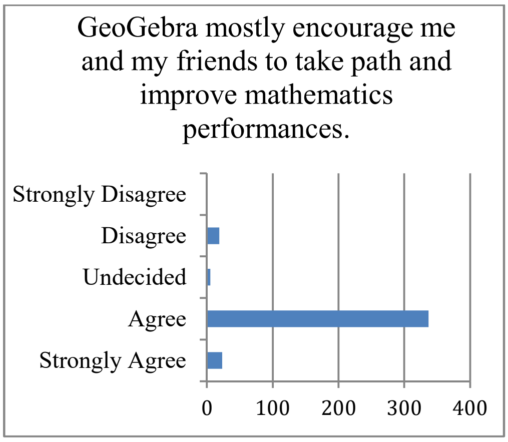
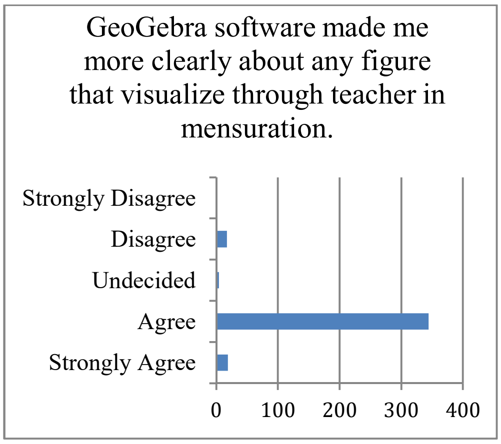


Figure 5.19 (iii)



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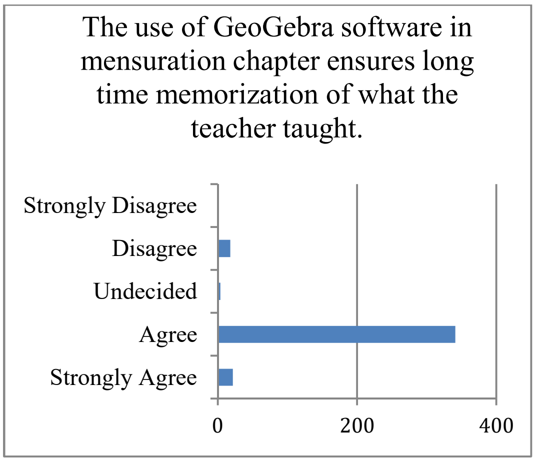

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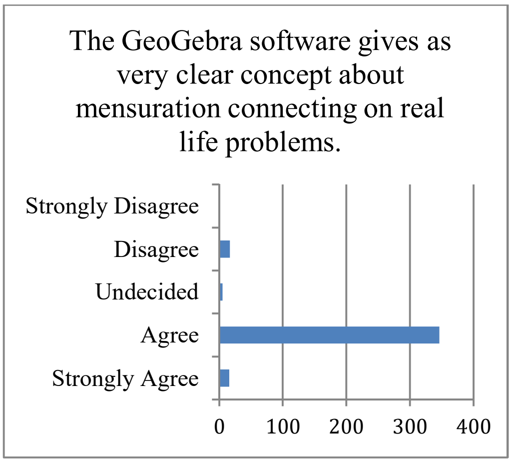

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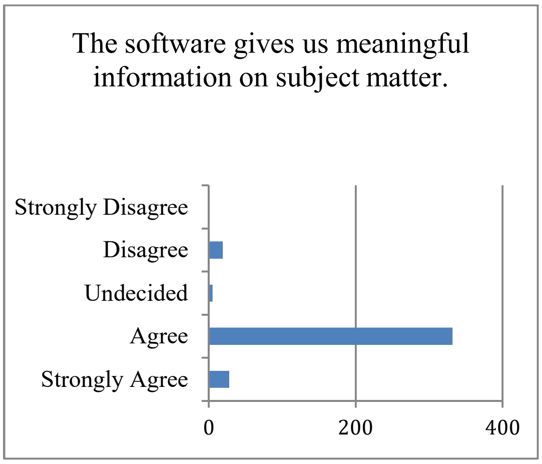

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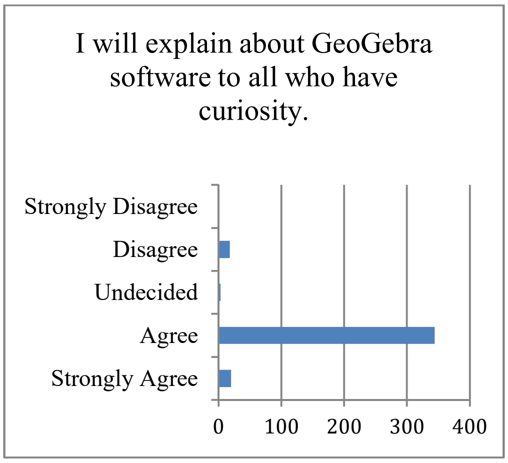

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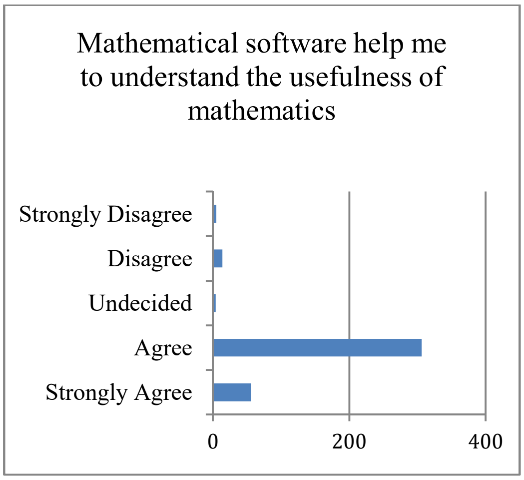

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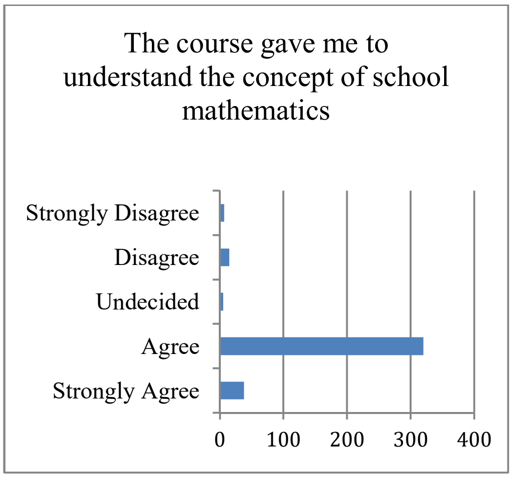

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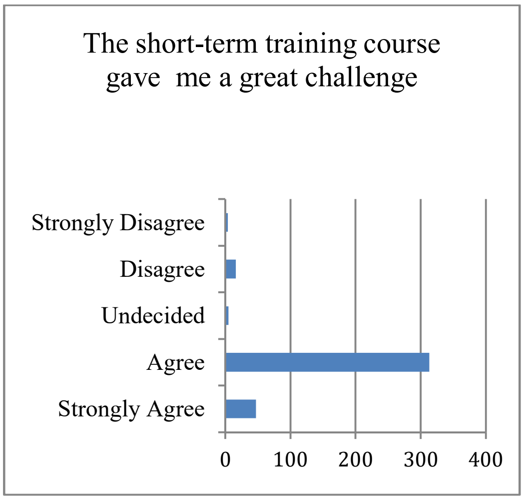


Figure 5.19 (xi)

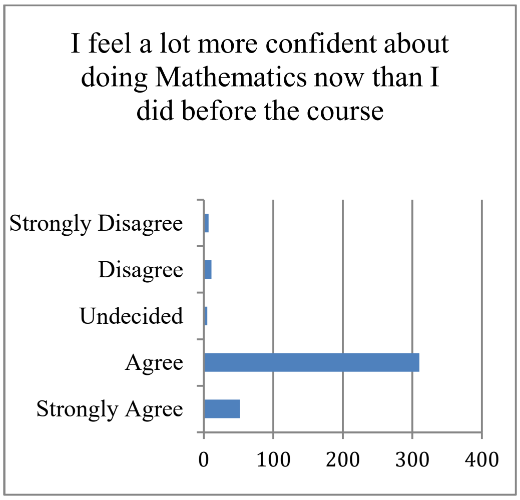


Figure 5.19 (xii)

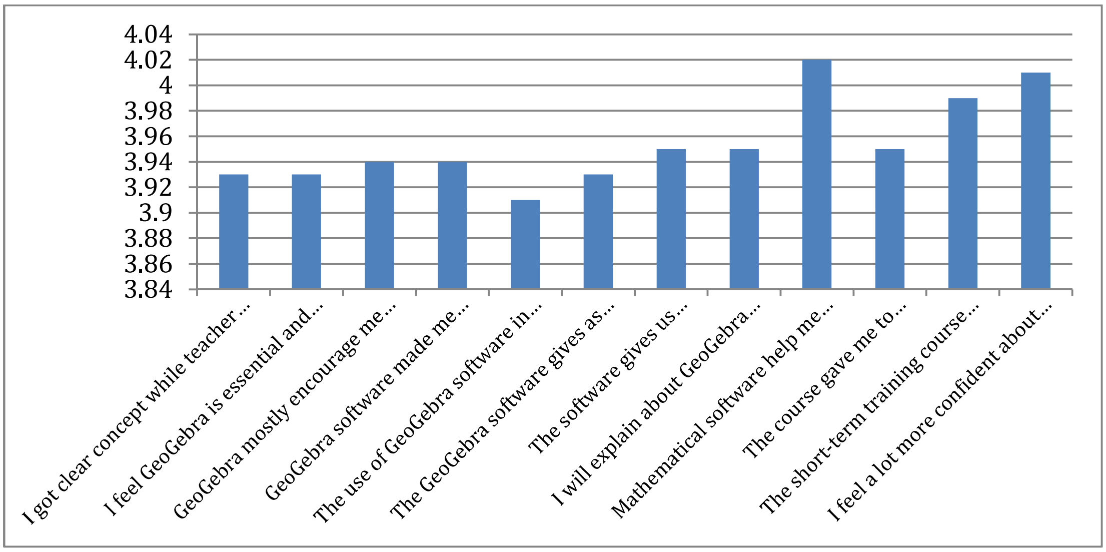


Figure 5.20: Weighted Mean of Students' perceptions relating to implementation of GeoGebra software in Mathematics Classroom.

It is found that the weighted mean of all the twelve statements was found greater than three. It is also found verified that the calculated value of χ^2=4830.50 is greater than the tabulated value of 60.48 at a 0.05 level of significance. So the null hypothesis is rejected and this implies that the students rated the implementation of GeoGebra software in Mathematics classroom as magnificently effective. In addition, the table showed that the statement "Mathematical software helps me to understand the usefulness of mathematics and I feel a lot more confident about doing Mathematics now than I did before the course" has the highest weighted means of 4.02 and 4.01 respectively, which means that most of the respondents agreed on the above statement and vital for their learning techniques with GeoGebra in Mathematics classroom. Moreover, to apply mensuration in real life problem was not an easy task for secondary students, but the statement of question 6 "the GeoGebra software gives a very clear concept about mensuration connecting on real life problems" with a weighted mean (3.93), has high level of agreement to solve their problem easier with using GeoGebra software Mathematics classroom. Furthermore, 100% of the surveyed students of the respondents agreed on the effective use of GeoGebra software in mathematics classroom and the use of ICT helps them to improve learning with more updated materials.

Table 5.5: Students' suggestion relating to implementation of GeoGebra software in Mathematics Classroom.

Questions	Statements	SA	A	U	DA	SDA	Weighted Mean	Remarks
1	I want to learn this software to make clear concept in mathematics subject matter as much as possible.	30	330	5	19	1	3.96	P
2	Every school should use GeoGebra software to teach mathematics in effective way.	29	332	5	18	1	3.96	P
3	The curriculum should include GeoGebra software in computer science subject for further study.	25	337	4	19	0	3.96	P
4	Mathematical software must be Included in the curricula	39	325	4	12	5	3.99	P
5	Questions using software and Application should be included in Examination	61	305	4	9	6	4.05	P
	Average	**60.96**	**76.25**	**101.53**	**153.60**	**312.20**		

Figure 5.21 (i) to (v): Bar graph representation of table 5.5.

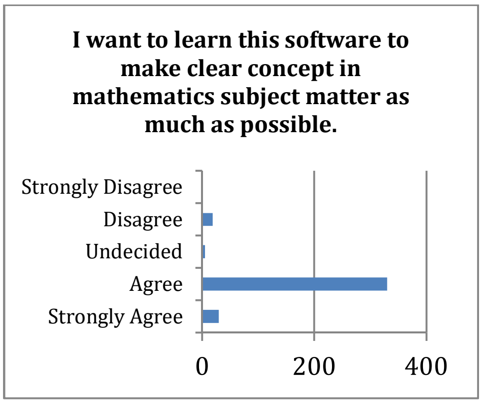


Figure 5.21 (i)

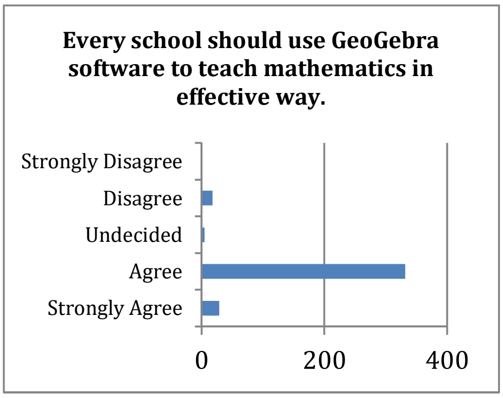


Figure 5.21 (ii)

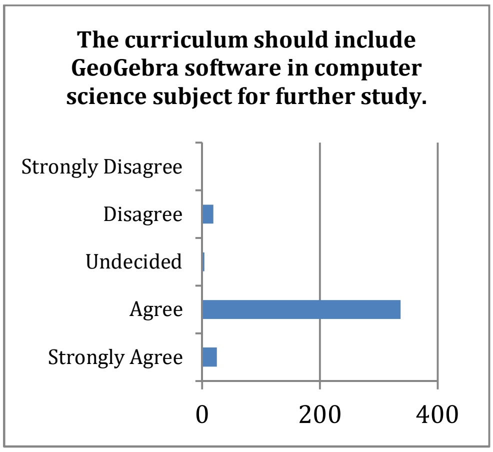
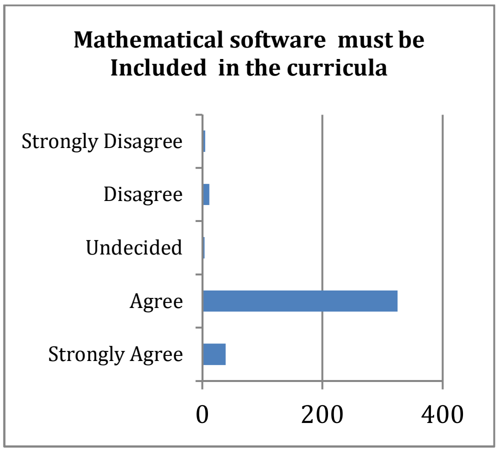


Figure 5.21 (iii)



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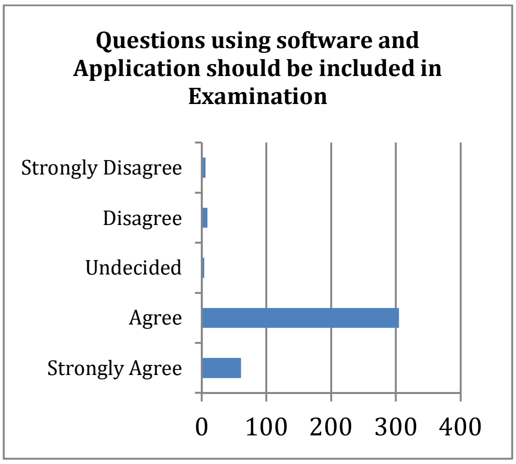

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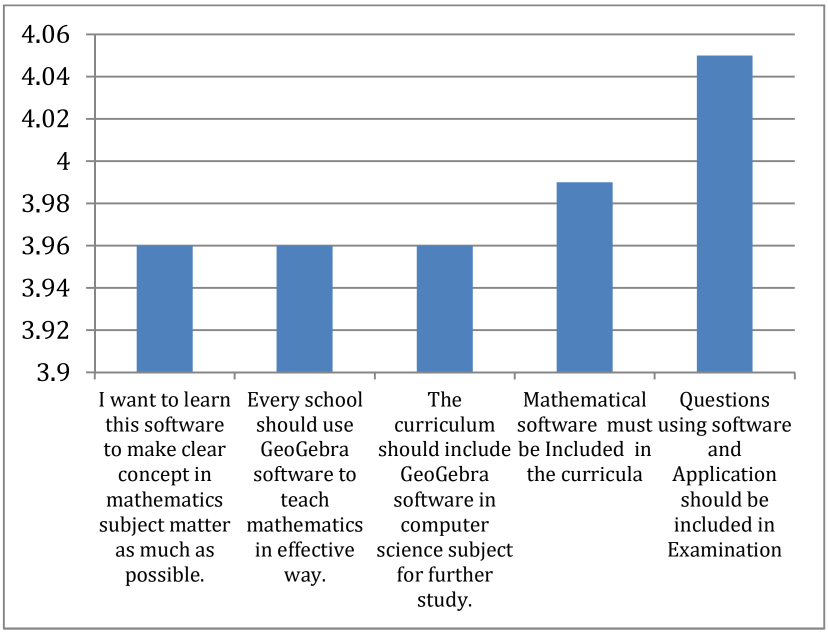

Figure 5.22: Weighted Mean of Students' suggestion relating to implementation of GeoGebra software in Mathematics Classroom

Table 5.5 showed that the students' suggestion on GeoGebra software integration after its implementation in Mathematics classroom. As reflected in the table above, question 1 has a weighted mean (3.96) which means that secondary students were enthusiastic to learn GeoGebra software to make clear concept in mathematics subject matter as much as possible. Question 2 with 3.96 weighted mean indicated that students agreed on the statement "Every school should use GeoGebra software to teach mathematics in effective way". Moreover, 94.03% of the students agreed that "The curriculum should include GeoGebra software in computer science subject for further study" with a weighted mean of 3.96. Furthermore, 94.81% of the students agreed that "Mathematical software must be Included in the curricula and "Questions using software and Application should be included in Examination" with 3.99 and 4.05 weighted mean respectively for the above two suggested statements.

5.6 Conclusion

The process of successful integration of technology into mathematics teaching and learning is progressing slowly and turned out to be rather complex. Today many students have access to computers and although appropriate software is available both in schools and at home, technology is rarely integrated substantially into everyday teaching. Being aware of the vital role that teachers play in technology-supported mathematics classrooms, professional development opportunities need to be adapted in order to prepare teachers better for new challenges of integrating technology into their teaching practices. The study described in this paper represents an initial step towards the goal of providing more successful introductory materials for professional development with dynamic mathematics software through identifying impediments that students face when being introduced to this new technological tool.

The findings of this research showed that the student-respondents had a positive perception regarding implementation of ICT integration in Mathematics classroom. The use of ICT integration had importantly significant roles in making the students more independent or autonomous. The perception of students also revealed that they were well motivated and enabled them to be more active and engaging in the lesson through ICT integrated learning in Mathematics classroom. The use of ICT helps them to improve learning with more updated materials. The students also found that implementation of GeoGebra software was essential and important for teaching mathematics and the software encouraged them and improved their mathematics performances. Finally, this research showed that the student-respondents rated the effectiveness of the ICT integration as effective means of learning in Mathematics classroom. Hence the implementation of ICT integration in Mathematics classroom is recommended for its further practical use especially for the secondary students. Future technology advancement need to focus on incorporation of technology into school curriculum via student-centered pedagogy while attending to many contextual conditions under which teaching and learning takes place (Palak & Walls, 2009).

CHAPTER 6

SUMMARY AND CONCLUSION

In this chapter, the finding on the performance of HSLC candidates in the Board Examination with a focus on Mathematics subject and teaching and learning of Mathematics in Mizoram have been discussed. It emphasizes on the implementation of Information and Communication Technology in Mathematics teaching and learning. The major concern of the research study was to reveal the status of Mathematics at the Secondary level and to explore new techniques of integrating technology in Mathematics Teaching and learning. The primary approach for the study was to investigate the performance of the candidates in HSLC Examinations since inception, and the level of use of ICTs, availability and barriers of ICT in teaching Mathematics by the teachers at school level in Mizoram. The concerns discussed also included exploring the ways in which the teachers incorporate software in Mathematics teaching; how effective it is; the problems coming in the way and many other issues.

The domain of the study is Mizoram state. For conducting the research, the performance of HSLC candidates under MBSE from the year 1978 to 2021 was collected from MBSE. Then the collected data was analysed using suitable statistical tools.

To investigate the present situation of ICT usage in teaching and learning, survey was done in which the participants chosen comprised of the Head of Institutions and Mathematics teachers in Mizoram. The data collected from the respondents was mainly through a structured questionnaire and opinionaire. It also focused on the different factors influencing the integration of ICT tools in teaching and learning of Mathematics. This proved to be of great help to understand the circumstances.

6.1 Major Findings of the Research Study

The research study was done using collected data. The major source of data collection for the research study was data collected from government records, journal, books, internet, a questionnaire and an opinionnaire. The data collected through different sources was analyzed applying quantitative and qualitative analysis. From the data collected through the survey, some observations could be done. The major findings of the research study are:

6.1.1 Finding related to HSLC examination result: From the 43 HSLC examinations conducted by MBSE from 1978 to 2021, data were collected from MBSE for analysis.

- It was found that out of 43 HSLC Examinations conducted by MBSE since inception, the mean score of HSLC candidates in Mathematics is lowest compared to other subjects in 35 examinations, Social Studies in 5 examination, Science in 1 examination and English in 2 examinations.

- The pass percentage of HSLC candidates in Mathematics subject is lowest compared to other subjects in 31 examinations, Social studies in 6 examinations and Science subject is also lowest in 6 examinations. This shows that Mathematics score of the candidates is worst among all other subjects in almost all the HSLC Examinations conducted by MBSE during 1978 to 2021.

- The degrees of relationship between subjects are calculated by using Pearson correlation coefficient. For Mathematics subject, it is observed that the correlation coefficient is highest with Science subject (i.e. 0.796), which is positive and also significant at 1% and 5% level of significant indicating that if the score of science subject increase the score of mathematics subject will also be increase among the students. The smallest correlation coefficient observe between Mathematics subject and Modern Indian

Language with value 0.526 indicating that among all the major subjects, which has least impact on scoring higher marks in Mathematics. For English subject, the highest correlation coefficient observe with science subject indicating that if English score increase, science score will also be increased. For social science, the highest correlation coefficient observe with science subject with value 0.792, indicating that increase in science score will result in increase in social science also. But, for English subject, the correlation coefficient is highest with MIL, indicating that two languages are highly correlated. Generally, if they score good mark in English, they have the chance to get good mark in other language subject also.

- Regression analysis is also used to find the relationship between Mathematics subject and other subjects. The highest regression coefficient was observed in science with 0.530, which mean that if the score of science increase by one mark, mathematics score will be increased by 0.530 marks. The other significant variables which are contributing for the increase of Mathematics score are years, social science subject, English and Mizo. But, gender is not significant for the score in mathematics mark. The value of the coefficient of determination (R^2) is also obtained and it is 0.673 indicating that subjects of science, social science, English, Mizo, gender and years account for 67.3% of the total variation in mathematics mark. This means 32.7% is not accounted by other subjects, gender and years. This may be due to some other unknown factors related to studies.

- Regression analysis by stepwise method showed that in the first step, Science is entered in the model and selected as the most important covariate out of 6 variables. In the second step, in addition to Science, English is entered in the model. In the third step, social science added to the science and English. In the fourth step, Mizo added to the science, English and social science and in the last step, science, English, social science, Mizo and years are entered in the model and these five covariates comprise the best set of the covariates which can explained the score of mathematics.

- A time series analysis of the results of appeared candidates in matriculation/HSLC Examination in Mizoram from 1978-2021 has been done by Box-Jenkins ARIMA model. From the analysis, It is found that ARIMA (0,1,1) Model is the best fit model for male and female candidates respectively in our study. Firstly raw data are differenced to eliminate non-stationary (Dickey-Fuller = -2.2172,-2.0008 and p-value = 0.4878, 0.5735 for male and female respectively) and confirmed stationary by performing ACF and PACF Plot of differenced data and also performed Dickey-Fuller test. It is found that Dickey-Fuller = -4.1656, -3.7631 with p-value = 0.01231, 0.03171 for male and female respectively, therefore the null hypothesis of non-stationary is rejected and then it has been concluded that the time series data is stationary. Then the parameter was estimated and after that Diagnostic test was performed followed by residual analysis. Then the pass percentage of both male and female candidates in HSLC Examination for the next Five years namely 2022, 2023, 2024, 2025 and 2026 was forecasted respectively along with their 95% prediction interval. The corresponding forecasted pass percentage for male is 73.33 with 95% lower and upper prediction limits 54.95 and 95.82 respectively and pass percentage for female is 77.57 with 95% lower and upper prediction limits 61.80 and 93.34 respectively. It is also observed that female candidates will have increase pass percentage as compared to male candidates in the next five years; it will be very challenging for male candidates.

6.1.2 Finding regarding availability and barriers of ICT for teaching and learning in schools of Mizoram:

There are 4422 schools from Primary schools to Higher Secondary schools in Mizoram state in 2020-21 as per UDISE Plus data. Out of these 3512 are Elementary (1956 is Primary Schools and 1556 Upper Primary schools) and 910 are Secondary Schools (712 Secondary and 198 Higher Secondary schools). There are 33 Central schools which are not under the government of Mizoram. Besides 748 elementary schools within Lawngtlai and Siaha districts are under District council administration and so, they are not included in the study. So, the total schools under study are 3641 schools. The study was carried out during July to September, 2021. 1490 schools responded the questionnaire which is 40.90% of the population under study.

- It was found that most of the schools have electric connection (power supply), 242 schools (16.2%) do not have power supply. 60.2% have computer or laptop. Only 14.5% have LCD projector. 11.9% have internet connection and 15.3% have interactive board. Almost all the schools do not have educational software, only 3.4% have educational software. Only 9.6% have ICT enabled classroom. A very few schools have YouTube channel (3.6%). However, most of the schools have WhatsApp group for teaching-learning. Only 10.8% are using Facebook/ Instagrams and 22.9% possess computer room or lab.

- Access to the technology (software and hard ware both) itself is the most important component in the use of ICT and the data revealed that internet and software/hardware are not available to the extent. Computers were available but teachers reported that accessories required for ICT integrated teaching and learning are not available in most schools. Majority of the schools have either no or disruptive internet connectivity which makes the use of ICT difficult especially during the covid-19 pandemic.

- It was observed that the main barriers of using ICT in schools are - Lack of funding, insufficient number of internet connected computers, not enough computers. Next to main barriers are - Insufficient number of the interactive whiteboard or any other educational software, Outdated, incompatible or unreliable computers, Inadequate space and infrastructural facilities, Inadequate training is given to the teachers for using ICT in the classroom, Lack of technical support or advice, Lack of administrative support, Lack of adequate skills of teachers, Lack of confidence regarding the use of ICT, The pressure to prepare students for exams and tests, Lack of flexibility due to time constraint and overload of work. Least barrier includes - No or unclear benefit of using ICT for teaching, Restrictive time table, Using ICT in teaching and learning not being a goal of the school, Lack of interest of teachers.

- Though the study does not cover all the schools in Mizoram, but this is the mirror that reflects the trend in most schools regarding ICT integration in teaching learning process in Mizoram. As far as institutional barriers are concerned, enough computers, internet connection, and technical support will facilitate them to overcome barriers to participate online learning. The government seems to have good intention but infrastructural provision is not as excellent as expected for the appropriate use of ICT. Implementation of the ICT Policy of School Education seems to be a distant dream unless adequate infrastructure, hardware/software is made available in the schools. Another important factor regarding the use of ICT is personal lack of confidence in using ICT. So, Proper training is also required for making ICT effective in education because the technologies are changing very fast.

6.1.3 Finding on the effectiveness of ICT on online mathematics teaching and learning in secondary schools of Mizoram during Covid-19 pandemic:

This part of the research was descriptive in nature. The population included secondary school teachers teaching mathematics within the state of Mizoram. The Information schedule and opinionnaire were sent out to the entire population. Out of these, 348 teachers responded. Since there was a total of 774 mathematics teachers at the secondary level and 71 mathematics teachers at the higher secondary level in Mizoram, the responses made up 41.1% of the population.

Based on the Information Schedule that was administered by the researcher himself, it was found that out of the 348 responses that came, male teachers made up 80.2% and only 19.8% of them were females. This in itself clearly proved the disparity still exists in a state like Mizoram, which is a state in the north eastern part of India, that a subject like mathematics which is a highly abstract subject, is still favored by the male of the population. Out of these, 23.9% from urban and 76.1% rural teachers were identified, and since the data was collected through the online mode using Google form, it showed that both localities had teachers who could deal with online technology. This in itself was a positive finding, strongly giving evidence that rural teachers were not far behind in dealing with ICT at least at this level. Secondary school teachers made up 91.1% of the responses and 8.9% were from Higher Secondary Schools.

- The study found that teachers were in extremely different positions in their compatibility to use ICT. While a good 65.5% of the sample teachers could make their own e-content in their smart phones, there were still nearly 12% of them who did not know how to use a computer, let alone create their own e-content. 99.7% were having smart phones. The fact that only around 54% of the sample teachers had received ICT training revealed the huge backlog when it came to ICT training. Since 53.2% of them still found it difficult to use

ICT to teach, it was clear that ICT could not be used as a mandatory part of teaching, in view of the high percentage of teachers who still did not know how to make use of them. The majority of 77% of the teachers who could even make their own teaching videos put the state in a good position but also highlighted that teachers were in extremely different positions when it came to ICT compatibility. Also, nearly half of the teacher still did not have their own computers at the time this study was done; strongly indicate that they did not consider an investment in computer as necessary or wise. This in itself was rather disheartening, because it brought into light the lack of education even among teachers themselves, in the utility of ICT.

- It was observed that majority of the teachers could make use of various online Apps to teach mathematics; it was troublesome to find 25.9% still could not make use of the online mode of teaching due to connectivity issues. Although 70.1% of the teachers were of the opinion that they could continue classes regularly, a larger 80.5% of them still felt that COVID-19 pandemic was a huge barrier to the teaching of mathematics, clearly indicating that although they could manage online classes they still preferred offline classes. It was not surprising that only 7.8% of them were of the opinion that online mode was better than offline mode. Although 94.5% of them gave home works in the online mode, only 65.2% of them enjoyed using ICT to teach, strongly supporting the fact that knowledge does not necessarily mean enjoyment. A small majority of 65.5% were indeed of the opinion that online teaching should be used as a supplement to offline teaching even when the pandemic is over but clearly many persons in this group belong to the ones who were of the opinion that COVID-19 is a barrier to the teaching of mathematics. All of these responses clearly point to the fact that majority of the teachers, even though they could carry on online teaching, still preferred the traditional classroom teaching and did not consider online mode of teaching as worthwhile if the situation did not demand it.

- In the present situation, ICT was enjoyed by students, as perceived by teachers, as a mode of teaching. Teachers themselves felt that less than half of the students had good internet facility. There were still 35.1% of students who did not have at least one mobile phone at home. This meant that these students had to either blindly study on their own or go to their friends who had mobile and internet when classes were carried out. It did not take deep thinking to deduce that this was the situation in most rural areas where parents are at lower economic level and internet connectivity is weak. It was of 30.7% of the teachers' opinion that students preferred online to offline classes. But the larger 69.3% of the students were clearly not in favour. Keeping in mind that nearly 35.1% of them did not have a mobile phone at home, it was natural for these groups of students to prefer offline teaching to online teaching. Since online classes were necessitated by the pandemic, it was inevitable, but it was clear that 73.3% of the students, even among the ones who had good connectivity had a problem with online classes. The students' achievements, looking at their examination marks, however, did not indicate any downward or upward change because of online classes. It was surprising; looking at their opinion in other questions, that 39.4% of them felt that students' achievement improved after online classes. And students also enjoyed ICT enhanced classes according to their own teachers. The only thing was that they did not want it to replace offline teaching. In fact, 85.6% of the mathematics teachers could see that their students did not understand mathematics through the internet. This could be due to poor connectivity or even the lack of personal touch in education through the internet.

6.1.4 Finding on the effectiveness of ICT in teaching and learning of Mathematics

For this study, secondary students from three High Schools – Govt. Mizo High School, Govt. Zemabawk High School and Govt. Chaltlang High School were engaged through online mode using Zoom. Mathematics teachers from these schools help the researcher in conducting classes for application of mathematical softwares.

- The student had a positive perception regarding implementation of ICT integration in Mathematics classroom.
- The use of ICT integration had importantly significant roles in making the students more independent or autonomous.
- The perception of students also revealed that they were well motivated and enabled them to be more active and engaging in the lesson through ICT integrated learning in Mathematics classroom.
- The use of ICT helps them to improve learning with more updated materials.
- The students also found that implementation of GeoGebra software was essential and important for teaching mathematics and the software encouraged them and improved their mathematics performances.
- Finally, this research showed that the student-respondents rated the ICT integration as effective means of learning in Mathematics classroom.

6.2 Suggestions that can be emphasized from the findings of the research study:

- The teachers should integrate ICT tools in Mathematics teaching.
- The teachers as well as the students should be made aware of the skills required for using ICT tools.
- The teachers as well as the learners should be provided with ICT equipments like computers, tablet etc. with access to internet.
- The Students should be assigned task wherein they can interact, collaborate and share their work with the fellow students via softwares like Geogebra etc.
- Teachers should provide learners with situations like making presentations or project work wherein they can express their ideas and opinions with the help of ICT tools.
- Teachers should be given training so that they can make e-contents and master themselves in content delivery.
- Blended mode of teaching and learning should be introduce in schools in which traditional teaching method and ICT application in the classroom should be practice with a proper balance while teaching.
- Since 99.7% of the teachers participated in the study are having smartphone, it may be a right time to integrate teaching of mathematics using their own smart phone with the help of smart television in their classroom. This will be extremely cost effective and will be affordable for almost all the schools. Reliable online repository may be helpful for this and the government is advice to create an online repository where teacher can access through their smart phone.

- The government of Mizoram may take necessary action in removing digital divide, providing power supply to all schools, frame practical and feasible IT integration programme and allocate fund for ICT infrastructure with internet connectivity for all the schools.

- The government of Mizoram may host a website for e-content repository where teachers and students may search study materials and lectures.

- Mathematics department of Universities may initiate research in Mathematics Education to address the problems on teaching and learning of Mathematics so that the teaching community may benefit in teaching and learning of Mathematics.

- Since research in Mathematics Education is pursued mainly from three departments – Education, Mathematics and IT. Better finding may be achieved from joint effort of these departments, coordinating with the concerned government departments, especially in the ICT application related. Universities and higher authority may take necessary action for funding joint research project for this.

6.3 Significance of the Research

This research study addresses some major concerns and issues in Mathematics teaching and learning in Mizoram, where even today it is treated as the hardest subject. Like other parts of the country, teaching Mathematics is a great task in Mizoram too. Students always have a sense of fear and failure, mathematics phobia is also a well-known issue among majority of the students. So now it is the time when teachers should switch on to innovative teaching techniques and methods using ICT. This approach of teaching will enforce and motivate students for technology based learning.

Today's students are techno literate, they can be called techno savvy whose lives are surrounded by gadgets like cell phones, Ipods, laptops, etc. Students utilise

ICTs in many areas of their lives. They communicate with each other through stuffs like mobile phones, computers, social media and such other forms. The communication and collaboration to others through ICT, at their computers and smart phones has expanded beyond the fixed platform. The research was carried on the basis of the fact that if students can use ICT tools meant for communication and updating information in their day to day life, why can't it be incorporated in teaching and learning of Mathematics inside and outside the classroom? It can be through simple mathematics tools and software or incorporation of secondary sources of communication and interactions like social networking, text chat, RSS feed, email and a lot more, all made possible across the internet. It is essential that opportunities are provided to them to explore technology and encourage them to use it as a learning tool. Many students who are not particularly skilled or successful in written expressions prove themselves to be quite talented while learning through technology as a medium. Expressing oneself through technology mode using ICT is a legitimate skill, and the opportunity to develop and demonstrate such skill should be made available to the students (Dwight L Burton, 2003). ICT is most effective when embedded in the curriculum and integrated into units of work (Dickinson, 1998). Mathematics teachers can maximize the impact of ICT in their classrooms by ensuring that they and their students use ICT as an integral part of lessons, present ideas dynamically using a range of media (Becta, 2006). Therefore ICTs should be integrated in such a way for purposeful application and meaningful engagement with the technology wherein its use will consolidate and extend students' learning.

6.4 Limitations and suggestion for further research

The research study was conducted in one of the states in India i.e. Mizoram. The domain selected for the research study was secondary level of education in Mizoram. It covered urban and rural areas. This was done considering the contemporary stature of education throughout the country. It is almost the same, showing minute variations in it. The factors responsible for this may be sometimes the socioeconomic ones or based on whether it is an urban area or rural place. These factors affect the availability of sources allowing teachers to adopt new methods and strategies of teaching which will cater the needs of the learners.

There is a lot of scope for the researchers in future who aspire to work on the issues and concerns in the same area i.e. information and communication technology usage in mathematics education. A wide range of study and research work can be conducted in this topic. The future researchers can conduct research on issues like the impact of Information and Communication Technology in elementary up to college level education in Mizoram, Teachers' training institutes etc. Mobile learning will also emerge as a new field of study (Chiu et al., 2016). Blended mode of learning for Mathematics also need research backup.

The following questions need to be address from different study angle. Could ICT improve our teaching and learning of mathematics? Should we use it occasionally or constantly? How can fast growing technology be used efficiently? Can we design tasks in a similar way with this new technology as it was the case with paper and pencil technique?

6.5 Role of Teacher

The teacher's job while integrating ICT in Mathematics class is that of a facilitator. For the teacher, ICT can benefit in a number of ways. Using presentation software enables teachers to show ideas dynamically and also deliver the content effectively. The use of ICTs in the classroom signals a shift from the conventional position of power held by the teacher to a more collaborative approach to learning. ICT based activities allow the teacher to assume the role of a facilitator whilst students take on an increasing responsibility for their own learning. The use of computer based technologies can shift the emphasis of activities from the teachers towards the students; enhance social interaction and empowering especially students with low literary skills (Interactive Education, 2006).

The Mathematics teacher who himself is aware of new upcoming technologies of teaching Mathematics will encourage students to seek information from the latest sources. Practice and use of ICT tools can also help students with problem solving. In this way teachers can eliminate the need for rote learning. Teachers must acknowledge the role of technology in helping prepare students for the future. Its use in the classroom makes learners feel confident through interactive activities, eliminating factors such as fear, phobia for Mathematics, shyness and lack of confidence within the learner. Apart from this, activities involved in ICT based teaching-learning prepare learners for future when they enter the real work force.

6.6 Conclusion

In conclusion, ICT has a positive impact on Mathematics teaching and learning. It has the potential to change the present day scenario of Mathematics teaching and learning in Mizoram. It can make students proficient in the mathematical thinking and practice through effective and efficient teaching in the classroom and encouraging extended learning practices outside the classroom. Therefore it is recommended that the teachers of Mathematics should try and incorporate ICT tools discussed in the research study which will definitely elevate the level of Mathematics teaching and learning. ICT facilities like Computer, tablet, Smartphone etc. may be made available to students. The government should provide internet connected ICT tools to educational institutions and more smart class, computer lab and digital learning materials.

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ABSTRACT

EFFECTIVENESS OF ICT
IN MATHEMATICS EDUCATION IN MIZORAM

AN ABSTRACT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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ABSTRACT

EFFECTIVENESS OF ICT
IN MATHEMATICS EDUCATION IN MIZORAM

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In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Mathematics of Mizoram University, Aizawl

ABSTRACT

Mathematics education is a vital concern although only limited research is available for studying this topic particularly in Mizoram. It is a great concerned to the society as a whole to improve the teaching-learning of Mathematics to achieve better result and better understanding of the mathematical concept. Because of these, urgent steps need to be taken in order to improve mathematics education in Mizoram. Practical and feasible suggestion for improvement of Mathematics Education is also the immediate need in school education in Mizoram. Only few researches can be found in the use of ICT in mathematics education in the context of Mizoram. In view of the problem faced by students and teachers in the teaching and learning of mathematics in Mizoram and to give responds to a number of questions regarding the study of this subject, the present study may be stated as **"Effectiveness of ICT in Mathematics Education in Mizoram".** The following objectives are taken up in the thesis:

1. To collect dataset from Mizoram Board of School Education (MBSE) to know the subject wise performance of all the candidates in the Board examination since inception.

2. To analyse the data collected using statistical tools.

3. To study the effectiveness of the use of ICT for learning mathematics at school level.

The first chapter is the general introduction of the thesis which includes mathematics education in India and Mizoram state, ICT and mathematics education, ICT initiatives in Mizoram, review of related literature, statement of problem, research questions, research objectives, methodology and operational definition of key terms.

In Chapter 2, High School Leaving Certificate (HSLC) Examination results under Mizoram Board of School Education (MBSE) from the year 1978 to 2021 were analysed using Excel and SPSS 20 softwares. Comparison of the score of the candidates in Mathematics and other subjects was investigated and it was found out

that candidates performed worst in Mathematics subject. Correlation and Regression analysis was also performed. Finally, time series analysis using Autoregressive Integrated Moving Average (ARIMA) from 1978 to 2021 was done to forecast male and female pass percentage of HSLC examinations for the next five years i.e. 2022 to 2026.

In Chapter 3, availability and barriers of ICT for teaching and learning in schools of Mizoram was assessed. It was a descriptive study in which questionnaire was developed for Head of institution of all schools under the government of Mizoram. No sampling was made in this study. A questionnaire was developed using Google form and was sent to the Head of Institutions using email and whatapps. Out of 3641 schools, 1490 schools responded which is 40.9% of the population under study.

In Chapter 4, effectiveness of ICT on online Mathematics teaching and learning in secondary schools of Mizoram during Covid-19 pandemic was investigated. The study is an effort to find out the effectiveness of ICT in online mathematics teaching and learning in secondary schools of mizoram during covid-19 pandemic. This part of the research was descriptive in nature. The population included secondary mathematics teachers within the state of Mizoram. The Information schedule and opinionnaire were sent out using Google form. 348 teachers responded out of 774 mathematics teachers and the responses made up 41.1% of the population.

In Chapter 5, effectiveness of ICT in teaching and learning of Mathematics was investigated. For this study, secondary students from three High Schools – Govt. Mizo High School, Govt. Zemabawk High School and Govt. Chaltlang High School were engaged through online mode using Zoom. The methodology used in this chapter is to form online module for students of secondary level and teach their current mathematics syllabus using Teachmint, Microsoft Office, Smartdraw and free mathematical software GeoGebra, and finally students' response of the questionnaire was analyse using statistical tools to predict the effectiveness of the module for teaching and learning mathematics. A five points Likert response was employed with a scale of Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree and analyzed the collected data by using weighted mean, percentage and Chi-square test at 0.05 level of significance to test the formulated hypotheses in this study.

Online Module administered in this study were:

1. Construction of tangents to a circle from a point outside it
2. Solving Linear Equation
3. Solving Quadratic Equation
4. Coordinate Geometry
5. Section formula
6. Area of a Triangle
7. Theorem of Thales
8. Pythagorean Theorem

The following hypotheses were formulated in this study:

1. **H_0**: There is a negative perception of students relating to the implementation and output of ICT integration in mathematics classroom.

   H_1: There is a positive perception of students relating to the implementation and output of ICT integration in mathematics classroom.

2. **H_0**: There is a negative perception of students relating to the implementation of GeoGebra software in Mathematics Classroom.

   H_1: There is a positive perception of students relating to the implementation of GeoGebra software in Mathematics Classroom.

Using Chi-Square test, the null hypothesis was rejected and this implies that the Secondary students have a positive perception towards ICT integration in Mathematics classroom and that the students rated the implementation of GeoGebra software in Mathematics classroom as magnificently effective. This research showed that the student-respondents rated the ICT integration as effective means of teaching and learning of Mathematics in the classroom.

Chapter 6 is summary and conclusion.

Finally, list of references is given at the end.