The Effect of Integrating Instructional Technology into Mathematics Classroom on Trainees' Pedagogy Content Knowledge at Arbaminch College of teachers' education (SNNPR)

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June, 2011

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF MATHEMATICS EDUCATION

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A THESIS SUBMITTED TO ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF EDUCATION IN MATHEMATICS

June, 2011

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Acknowledgements

I would like to express my heartily felt gratitude to my advisor Dr. Solomon Areaya for his genuine support and advice, which made this thesis complete and possible.

I would like also to acknowledge my co-advisor Ato Kassa Michael for his keen interest and his valuable advices to make this study successful.

My deepest appreciation has to go to the administrative staffs and teachers of mathematics at AMCTE for hosting me to do my study and for the help they provided me during my data collection period.

My heartfelt thank has to go again to my wife Melesech Mekuria, for her keen support taking all the responsibilities of our children and to her prayer to the success of my study.

I would like to acknowledge first year MNSR trainees for filling the questionnaire and to their cooperation during the lesson delivery while I was conducting an experiment.

I would like to acknowledge AAU, for providing financial support to this study.

Thank you!!

Table of contents

Contents **page**

Acknowledgements.....i

Table of contents.....ii

List of tables.....v

List of figures.....vii

Acronyms.....viii

Abstract.....ix

Chapter One: Introduction.....1

1.1Background.....3

1.2 Statement of the problem.....5

1.2.1Hypothesis.....6

1.2.2 Objective of the study.....6

1.3 Significance of the study.....7

1.4 Delimitation of the study.....7

1.5 Limitations of the study.....8

1.6 Definition of Terms.....8

Chapter Two: Review of Related Literature.....9

2.1 Introduction.....9

2.2 Preparing Mathematics/science teachers to teach with technology.....10

2.3 Effective Technology Integration and Learning Theory.....11

2.3.1 Learning with Technology: Constructivist Perspective.....11

2.3.2 Learning from Technology: Behaviorist Perspective.....12

2.4 Conceptual Framework (The TPCK Framework).....13

2.4.1 Content Knowledge (CK).....14

2.4.2 Pedagogical Knowledge (PK).....15

2.4.3 Pedagogical Content Knowledge (PCK).....15

2.4.4 Technology Knowledge (TK).....15

2.4.5 Technological Content Knowledge (TCK) 16
2.4.6 Technological Pedagogical Knowledge (TPK) 16
2.4.7 Technology, Pedagogy, and Content Knowledge (TPCK) 16
2.5 ICT Tools of Particular Relevance to Mathematics Education 17
2.5.1. Spread Sheets 17
2.5.2 Calculators 17
2.5.3 Geometer's Sketchpad (GSP) 18
2.5.4 Fathom 18
2.6 ICT Development in Ethiopia 19
2.6.1 WoredaNet Initiative 20
2.6.2 SchoolNet Ethiopia 20
2.7 Teacher Education Program and the Mathematics Curriculum in Ethiopia 20
Chapter Three: Research Design and Methodology 22
3.1 Introduction 22
3.2 Study Area and Population 23
3.3. Subjects and Sampling Procedures 24
3.4 Data Collection Instruments 25
3.4.1 Questionnaire 25
3.4.2 Pre-test and Post-Test 26
3.5 Validity and Reliability of Instruments 28
3.5.1 The Difficulty Level of the Items 29
3.5.2The Discriminating Power of the Items 29
3.5.3 Reliability Coefficient for Internal Consistency 30
3.6 Methods of Data Analysis 31
3.7 Ethical Considerations 32
Chapter Four: Data Presentation, Analysis and Discussion 34
4.1 Introduction 34
4.2 Presentation and Analysis of Data Through Questionnaire 34
4.2.1 General Characteristics of Questionnaire Respondents 34
4.3 Presentation and Analysis of Pretest-Posttest Data 57
4.3.1 General Characteristics of Trainees Involved on the Pre-Post-Test 58
Chapter Five: Summary, Conclusion and Recommendations 77

5.1 Summary 77
5.2 Conclusions 79
5.3 Recommendations 79
References 81
Appendix A 82
Appendix B 85
Appendix C 88
Appendix D 93
Appendix E 94
Appendix F 96
Appendix G 98

List of tables page

Table 3.1: the pretest-posttest non-equivalent group design.....23

Table 3.2: First semester trainees' statistics in Mathematics stream.....24

Table 3.3: Content areas and a type of technology integrated during the treatment.....28

Table 4.1 Characteristics of questionnaire respondents.....34

Table 4.2 TK items and their chi-square test of independence.....36

Table 4.3.Discriptive statistics of trainees' responses on TK component.....37

Table 4.4 CK items and their chi-square test of independence.....39

Table 4.5 Descriptive statistics of trainees' responses on CK component.....39

Table 4.6 PK items and their chi-square test of independence 41

Table 4.7 Descriptive statistics of trainees' responses on PK component.....42

Table 4.8 PCK items and their chi-square test of independence.....45

Table 4.9 Descriptive statistics of trainees' responses on PCK component.....45

Table 4.10 TCK items and their chi-square test of independence.....46

Table 4.11 Descriptive statistics of trainees' responses on TCK component 47

Table 4.12 TPK items and their chi-square test of independence.....49

Table 4.13 Descriptive statistics of trainees' responses on TPK component.....50

Table 4.14 TPCK items and their chi-square test of independence 53

Table 4.15 Descriptive statistics of trainees' responses on TPCK component 54

Table 4.16 Descriptive statistics on trainees' responses for rating classroom technology.....56

Table 4.17 General characteristics of trainees involved on the pre-post-test 58

Table 4.18 Trainees' achievement level based on the previous Mathematics result 59

Table 4.19 Descriptive statistics of the pretest for both experimental and comparison group..... 60

Table 4.20 t-test for equality of a pretest mean score 60

Table 4.21 Paired samples statistics for comparison group (MNSR G1).....61

Table 4.22 Paired sample t-test for the difference of the two means (MNSR G1).....61

Table 4.23 Paired sample statistics for experimental group (MNSR G2).....63

Table 4.24 Paired sample t-test for the difference of the two mean scores of MNSR G2.....63

Table 4.25 Group statistics for High achievers 64

Table 4.26 Independent sample t-test for high achievers.....65

Table 4.27 Group statistics for medium achievers 66

Table 4.28 Independent sample t-test for medium achievers.....66

Table 4.29 group statistics for low achievers.....67

Table 4.30 Independent sample t-test for low achievers 67

Table 4.31 Group statistics for female trainees.....68

Table 4.32 Independent sample t-test for female trainees 69

Table 4.33 Group statistics for male trainees 69

Table 4.34 Test for compare mean difference of male trainees of the two groups 70

Table 4.35: Independent sample t-test for the mean difference of between groups 71

Table 4.36 Descriptive statistics for trainees' achievement levels 72

Table 4.37 ANOVA table for the three achievement levels 72

Table 4.38.Test of between-subjects effect (ANCOVA) 73

List of figures

page

Fig 2. 1. The TPCK framework and its knowledge component..... 14

Fig 4.1 t-distribution of difference of mean for MNSR G1.....62

Fig 4.2 t-distribution of difference of mean for MNSR G2 64

Fig 4.3 Curve fit for pre-posttest data set 74

Acronyms

- AMCTE: Arbaminch College of Teacher Education
- ANOVA: Analysis of variance
- CK: content Knowledge
- DV: dependant variable
- EMA: Educational media agency
- ICT: Information and communication technology
- IV: independent variable
- LCD : Liquid crystal Display(device used to project an output when connected with a computer)
- MNSR: Mathematics and natural science stream regular trainees
- MNSR G1: Mathematics and natural science stream regular group one
- MNSR G2: Mathematics and natural science stream regular group two
- MOE: Ministry of education
- NCTM: National council of the teachers of Mathematics
- OHP: Overhead projector
- PC: Personal computer
- PK: Pedagogical knowledge
- PCK: Pedagogical Content Knowledge
- REB: Regional education bureau
- SNNPR: South Nations, Nationalities and People Region
- TK: technology knowledge
- TPK: technology pedagogy knowledge
- TPCK: Technology, pedagogy, content knowledge

Abstract

The main purpose of this study was to investigate the effect of integrating instructional technology into mathematics classroom on trainees' Pedagogical Content Knowledge at Arbaminch College of teachers' education (SNNPR). To achieve the above purpose, a quasi-experimental design in general and a pretest-posttest non-equivalent group design in particular was used. The required data was collected using a pretest, posttest and students' questionnaire. The subjects of this study were first year Mathematics and natural science regular (MNSR) cluster diploma program trainees. These trainees were selected purposefully as intact groups. In order to increase the validity and reliability of the data collected, all the instruments listed above were first piloted in similar groups before the administration of the actual instrument. The data collected through questionnaire based on the five point Likert scale was analyzed using a descriptive statistics together with a chi-square test of independence. On the other hand, data collected using achievement test was analyzed using student's t-test, one-way ANOVA, ANCOVA and regression analysis using SPSS 15.0 and Fathom 2.1. The analysis of achievement test revealed a significant mean difference ($P<0.05$) between pretest and posttest scores of high and medium achievers among the experimental and comparison groups. However, this was not true for low achievers. The same analysis also showed a significant mean difference between male trainees among the experimental and comparison group. However, this is not true in the case of female trainees. The analysis of data through questionnaire also indicates a significant difference between the pre-and-post responses of trainees PCK after the intervention. Thus in this study it is strongly recommended that effective mathematics teaching-learning process in teacher education colleges should incorporate the use of instructional technology to enhance students' mathematics achievement and to develop their pedagogy content knowledge.

Chapter One: Introduction

The purpose of this study was to examine the effects of integrating instructional technologies into mathematics classrooms on trainees' Pedagogical Content Knowledge (PCK) at Arbaminch College of Teachers' Education. Arbaminch Teacher Education College is one of the four teacher education colleges in South Nations, Nationalities and People Region (SNNPR) state located in Gamo-Gofa Zone Arbaminch City which is 505 km away from the capital Addis Ababa preparing teachers for second cycle primary schools (grade five trough eight).

Technology is having an impact on every aspect of modern life. It is time to more fully integrate technology into the educational settings since skillful use of technology supports the development of process skills such as, higher order skills, adaptability, and collaboration that are essential to success in our rapidly changing information age. It is important to remember Dewey's words that "if we teach today as we taught yesterday, we rob our children of tomorrow" (Dewey, 1916).

ICT is very powerful resource which we, as mathematics teachers, should need to consider when planning work for our students inside and outside mathematics lessons. Many common ICT tools have been developed for personal use, and their deployment in a teaching environment requires careful consideration. Inspection evidence consistently shows very little use of appropriate ICT tools in mathematics teaching at all levels.

Of course different subjects will have different styles of ICT use to consider. For example, in mathematics we have hand-held devices such as graphical calculators and Geometric sketch pad, and whole-class teaching tools such as interactive whiteboards to consider. Whatever style of hardware use we choose; the key issue will be the choice of software to support the learning and teaching of mathematics.

Technology allows us to better serve the diverse learning styles of our students and educate them for a wider range of intelligence. Everybody has different learning styles for meaningful learning but teachers cannot represent all the styles in a traditional classroom environment. However, with the flexibility and help of the technologies, we can design learning environments in which students can manage and construct their own representations of knowledge in their minds.

Teachers need to use a variety of teaching activities in their classrooms, and that variety should include technology whenever appropriate. Technology can be used not only as an information management tool, but also as a means of reaching students of diverse backgrounds (Sianjina, 2000). Use of technology can help teachers relate to today's students who are very media aware, prompt new approaches to curriculum, and encourage developments in teaching skills (Schwarz, 2000). It can also assist teachers in helping students make connections with a worldwide community (Davidson, 2000).

In a study conducted by Iding, Crosby, and Speitel (2002), pre-service teachers reported using computers for their own personal use were at least moderately proficient with computers, and had access to computers at schools and in individual classrooms, and were interested in learning more about using computers and technology for instructional and educational purposes. However, they appeared to be unaware of educational software that could be helpful in their teaching, and the majority did not use technology in many teaching-related tasks, including student portfolios, tutorials, demonstrations and simulations, and student collaboration in class and with students at other sites. Whetstone and Carr-Chellman (2001) also found that computers were seen as important to education; however, pre-service teachers did not appear to see the importance of their own pedagogical roles in implementing computers in classrooms. They showed a lack of anxiety and a lack of motivation toward computers, despite the importance they placed on computers in changing schools.

When technology is used according to the Standards, it serves as a tool and allows students to focus on the mathematics (Heid, 1997). It is recommended by several experts in the area (Pringle, et al (2003) that the use of technology should start as early as possible.

There are many different ways to use computers and other technology tools to facilitate the learning of Mathematics in the teacher education colleges like Arbaminch College of Teacher Education (AMCTE). The focus of this study was to investigate the effect of integrating instructional technology with mathematics contents to enhance the trainees' Pedagogical Content Knowledge. Also this study will suggest future directions and opportunities for research in this area.

1.1Background

Electronic technologies are essential tools for teaching, learning, and doing mathematics. "Students can learn mathematics more deeply with the appropriate use of technology" (NTCM, 2000). The NCTM's Principals and Standards for School Mathematics-Technology Principle states: "Technology is essential in teaching and learning mathematics, it influences the mathematics that is taught and enhances students' learning" (NCTM 2000, Technology section).

The use of Computer-assisted instruction allow for students who have different learning styles to work together. Computer-assisted instruction provides individualized instructions permitting learners to monitor speed on a moment-to-moment basis, immediate feedback through which learners can monitor their response, accuracy on each question on the screen, and immediate reinforcement to motivate continuing on-task behavior. It also allows for individual differences in ability and rate of learning (Xin, 1999).

Research on technology integration in mathematics education has examined the effectiveness of spreadsheets and dynamic geometry software on achievement (Isikal & Askar, 2005), computers and 2D geometric learning (Olkun, Altun, & Smith, 2005), and dynamic geometry sketches (Sinclair, 2004). The findings of the studies support computers in mathematics teaching and learning. For example, Isikal and Askar (2005) investigated the effect of spreadsheet and dynamic geometry software on mathematics achievement and Mathematics self-efficacy. The results indicate that using technology effectively as a learning tool improves students' mathematics achievement. Olkun et al. (2005) found that students who did not have computers at home initially had lower geometry scores. Therefore, Olkun (2005) suggests that in schools, it seems more effective to integrate mathematical content and technology in a manner that enables students to do playful mathematical discoveries.

Similarly, Sinclair (2004) found that using the Geometer's Sketchpad activities helps students notice geometric details, explore relationships and develop reasoning skills related to geometric proof. Wang (2001) investigated that student teachers' perception and practice of the teacher's role when teaching with computers. The teacher's role was measured as teacher-centeredness and student-centeredness, and results showed a significant difference in computer use although no difference in perception of use.

Teachers' attitudes play an important role in using technology in teaching and learning

mathematics. It is very important to improve teachers' attitudes toward using computers in the classroom because it may enhance mathematics teaching and learning. However, many pre-service and in-service teachers are unfamiliar with the types of technology available for teachers. Also, many teachers lack the knowledge of how to properly incorporate technology in the classroom (Doering, Huffman, & Hughes, 2003).

A highly qualified teacher should be an effective teacher. An effective teacher will strive to learn new techniques, such as integrating technology appropriately, learning new pedagogical skills, staying current with curriculum, and attending workshops and conferences to network with other teachers, all in an effort to continue to be an effective teacher. An effective teacher is willing to step out of his/her comfort zone to try new techniques, technology, etc. Also, an effective teacher pushes the students out of their comfort zones to experience the new and different learning experiences with technology (Kennedy, 2004).

Math educators must provide thorough preparation for students in the world they face today and give them the proper tools to work with before they leave the classroom. Prospective teachers who engage technology as a teaching tool develop new perspectives on using technology in their teaching (Pringle et al. 2003).

According to Shulman(1986), to prepare to teach mathematics, teachers need an in-depth understanding of mathematics (the content), teaching and learning (the pedagogy), and technology. More importantly, however, they need an integrated knowledge of these different knowledge domains, the overlap and integration of these domains. TPCK for teaching with technology means that as they think about particular mathematics concepts, they are concurrently considering how they might teach the important ideas embodied in the mathematical concepts in such a way that the technology places the concept in a form understandable by their students.

However, when we consider schools in developing countries in general and in Ethiopia in particular in terms of technological development and development in general, a slow change has been observed. This may be a result of a number of factors that need research. This paper tries to address the way how to integrate mathematics lessons with technology in Arba Minch Teacher Education College for the benefit of both students and mathematics teachers.

1.2 Statement of the problem

The challenge for mathematics teacher educators is to identify teacher preparation and professional development programs that lead toward the development of technology pedagogical content knowledge (TPCK). TPCK is an important body of knowledge for teaching mathematics that must be developed in the coursework in teaching and learning as well as within the coursework direct at developing mathematical knowledge. Preparing teachers to teach mathematics is known by its complexities. What technologies are adequate tools for learning mathematics? What about teacher attitudes and beliefs about teaching mathematics with technology? What are the barriers? These questions and more frame the challenge for the development of a research agenda for mathematics education that is directed toward assuring that all teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology in the context of teaching and learning mathematics.

Research findings (Wenglinsky, 1998) revealed that when appropriately used, computers may serve to improve student mathematics achievement as well as enhance the overall learning environment of the school. Teachers who received training in the area of instructional technology were found more likely than those who had not to use computers in effective ways such as in simulations, applications, and math learning games. Wenglinsky (2000) also used the 1996 NAEP (national association of educational procurement) data to show the positive effects of using instructional technology to nurture higher order thinking skills in the mathematics classroom.

Unfortunately, Lederman and Neiss (2000) report that technology courses which are part of teacher preparation programs often emphasis teachers' learning about technology rather than the integration of technology into classroom teaching. As one can observe from the above two findings, this area is a problematic area which needs further investigation.

To this end the Ethiopian government has made a huge investment in ICT in schools over the past few years and was committed to maintain it. One aspect of this investment was an introduction of Plasma TV lessons in Secondary schools and Continued Professional Development opportunities provided for higher institutions including teacher education colleges. The program was provided by the educational media agency (EMA) in collaboration with the Ministry of Education (MOE).

Currently, there is a good beginning of using ICT for instruction in schools around cities in Ethiopia, however its implementation have a number of problems. Most school teachers in the countryside are not yet aware of what technology can do for instruction and what kind of technologies are there for classroom instruction. Moreover, from my own teaching experience (eight years) as a professional teacher educator at Arbaminch College of Teacher Education (AMCTE), the use of ICT by teachers for classroom instruction is not satisfactory. This could be for a number of reasons which this study was intended to answer. The following Hypothesis was drown to be tested in this study.

1.2.1Hypothesis

Based on the above, the following hypotheses were formulated.

1. There is no difference on the trainee's Pedagogy Content Knowledge (PCK) who learned mathematics with technology and without a technology (using lecture method).
2. There is no mean difference between the pre-test and post-test scores of trainees who learned mathematics with technology and without a technology with respected to gender and the previous achievement.

1.2.2 Objective of the study

- General objective:

➢ To know the effect of integrating instructional technology into mathematics classroom on 'trainees' Mathematics achievement and their Pedagogical Content Knowledge(PCK).

- Specific objectives:

➢ To explore the effect of integrating instructional technology into Mathematics classroom on trainee's pedagogy content knowledge.
➢ To examine the contribution of integrating technology into Mathematics on trainees' Mathematics achievement.
➢ To evaluate whether technology could be made an integral component or tool for learning mathematics or not.

1.3 Significance of the study

"Technology is an essential tool in teaching and learning of mathematics; it influences the mathematics that is taught and enhances students' learning" (National Council of Teachers of Mathematics (NCTM) 2000, Technology Principle). As the mathematical task is what should be problematic and not computations or graphing, technology is becoming a necessary tool in the mathematics classroom. For example, graphing calculators allow students to focus on the graphs of complex functions they develop in real-world applications without getting bogged down in the difficulties that may arise when graphing by hand. Students' use of technology to engage in real-world mathematics in turn allows them to design and construct their own mathematical experiences. This study was concerned with examining the effect of integrating instructional technology into mathematics classrooms on trainees' Pedagogical Content Knowledge (PCK) at Arbaminch College of Teachers' Education. Thus, it is hoped that the findings of this study will help in the following instances.

- It will help module/course writers at AMCTE, other teacher education colleges with similar status with AMCTE in the region, curriculum planners in particular and policy makers at large, to know how technology can be made an integral component of the teaching of mathematics.
- It will improve the current old traditional lecture method of teaching mathematics at AMCTE in particular, by showing the benefits of a specific technology tools (soft and hardware) for classroom instruction.
- It will also help and encourage other researchers to do more researches in this area by providing certain baseline information

1.4 Delimitation of the study

The study of this research is delimited to investigating the effect of integrating instructional technology into mathematics classrooms on "trainees" PCK at AMCTE. Thus, the findings of this study reflect the situation of students of mathematics at Arbaminch Teacher Education College. The researcher selected Arbminch College for the following main reasons.

- Has enough work experience in this college.
- Knows and trusts the existence of the problem under investigation in the college.
- Can easily access the required technology and other facilities.
- Can access information/data easily

1.5 Limitations of the study

In conducting this study, the researcher has faced some challenges, which contributed to the limitation of the study. Some of these were:

- lack of interest to fill the questionnaire and return the questionnaire back
- Shortage of lesson delivery time (Six weeks) was not sufficient to see the full effect of technology.
- Trainees' poor background of technology
- Intervention of college schedule during the lessons
- Interruption of power in the middle of the lesson delivery for experimental groups.

1.6 Definition of Terms

- **Educational technology**: The study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources. (Januszewski & Molenda, 2008, p.2).
- **Instructional Technology**: The theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning." (Seels & Richie, 1994, p. 1)
- **Technology tools**: hardware, software packages and devices that can be used to facilitate learning.

Chapter Two: Review of Related Literature

2.1 Introduction

This chapter deals with a review of related literature examining different research findings on the integration of instructional technology into mathematics teaching and learning. The literature review focuses on how technology affects perspective teachers' Mathematics achievement and develops their pedagogy content knowledge. The following aspects were considered as being important in this review:

- What constitutes an effective use of technology in a meaningful mathematics teaching and learning situation?
- What is Pedagogy content knowledge and why is it important for teachers?
- What benefits obtained so far from integrating instructional technology with mathematics?
- What problems do students encounter while they learn mathematics through technology?

To answer the above questions and get a full insight about general technology-mathematics integration the following review was made.

Research Findings revealed that when appropriately used, computers may serve to improve student mathematics achievement as well as enhance the overall learning environment of the school. Wenglinsky (1998) used data from the 1996 National Assessment of Educational Progress (NAEP) in Mathematics to study the effects of teachers' use of instructional technology on student achievement in mathematics. Teachers who received training in the area of instructional technology were found more likely than those who had not to use computers in effective ways such as in simulations, applications, and math learning games. Wenglinsky (2000) also used the 1996 NAEP data to show the positive effects of using instructional technology to nurture higher order thinking skills in the mathematics classroom.

Unfortunately, Lederman and Neiss (2000) report that technology courses which are part of teacher preparation programs often emphasis pre-service teachers' learning about technology rather than the integration of technology into classroom teaching. The need for teacher preparation programs to serve as catalysts for the integration of technology into classroom instruction is vital. Abilities, knowledge, and skills in teaching with technology need to be emphasized in the

preparation of teachers so that they can make informed decisions about which technology to use for specific teaching purposes.

Linking technology with curriculum has caused significant changes in teaching and learning. Wright (1999) reports higher student achievement, self concept, attitude, and teacher-student interaction as a result of interactive learning made possible via technology. Kerrigan (2002) has found the benefits of using mathematics software and websites to include promoting students' higher-order thinking skills, developing and maintaining their computational skills, introducing them to collection and analysis of data, facilitating their algebraic and geometric thinking, and showing them the role of mathematics in an interdisciplinary setting. As a result of such research, Neiss (2001) reports the National Council of Teachers of Mathematics pinpoints technology as an essential component of mathematics learning environment, influencing the mathematics that is taught as well as enhancing students' learning.

Teachers' ability to select appropriate software and websites is an essential component of the ultimate success of effectively integrating instructional technologies into classroom teaching. Ertmer, Addison, Lane, Ross, and Woods (1999) state that "teachers, not technology, hold the key to achieving integrated technology use," while Haughland (2000) states that how computers are used is more important than if computers are used.

2.2 Preparing Mathematics/science teachers to teach with technology

Science and mathematics teacher preparation programs expect their perspective teachers to develop both a depth and breadth in the content knowledge in science and mathematics. This initial content knowledge assumes basic skills and broad general knowledge of the subject along with knowledge of inquiry in the specific discipline. Increased research attention to teachers' subject matter knowledge has focused attention to how student teachers organize and inter-relate these subject matter facts, concepts, and principles (Ball,1991; Even, 1989; Kennedy, 1990; Leinhardt & Smith, 1985; Marks, 1990; Tamir, 1988; Wilson & Wineburg, 1988). However, perspective teachers develop their understanding of science or mathematics through classes aimed at the accumulation of knowledge. Whether these pieces of knowledge are interconnected in a manner that supports them in translating the knowledge and understanding into a 21st century curriculum

in a form accessible to learners is unknown as they begin their study of learning to teach their subject.

2.3 Effective Technology Integration and Learning Theory

Many discussions about technology and education have focused on the question of how technology facilitates teaching and learning. Honey and Moeller (1990) state that the most important element affecting how and whether teachers use technology in their teaching is their pedagogical beliefs on learning and instruction. They examined teachers` perceptions of how and why they do or do not use technology in their teaching and concluded that high-tech teachers engaged their students in collaboration, project-oriented work, hands-on activities, inquiry and discovery-based learning. They suggested a transition from traditional to constructivist paradigm in both teachers` beliefs and educational system in order to benefit from technology as much as possible. Hannafin and Freeman (1995) agree that teachers` beliefs about knowledge acquisition and effective uses of technology are correlated with the ways they use technology in their classrooms. The teacher's view of learning, then, could be another factor to successful technology integration.

2.3.1 Learning with Technology: Constructivist Perspective

In educational uses of technology, Jonassen and Reeves (1996) make a distinction between learning from computers and learning with computers. Much of the early research and development with technologies considered the enhanced learning that could be achieved when computers played an important and key role in delivering content and creating learning opportunities to help students make meaning and develop an understanding. In such settings, there was a distinctly diminished role for the teacher. Jonassen (1991) suggests that the more opportunistic and effective uses of technologies in classrooms are those where learning is achieved with the aid of technology, and the resulting environment is one where the technology supports and scaffolds the learning rather than being the object or derivative of the learning. McClintock (1992) also states that in a constructivist-learning environment, technology plays an acknowledged and purposeful role in the day-to-day activities, but does not become the object of instruction. When used in a constructivist manner, students utilize technologies to a) manipulate data, b) explore relationships, c) intentionally and actively process information, d) construct personal and socially shared meaning and e) reflect on the learning process (Jonassen, Peck & Wilson, 1999).

"The technological applications which support learning in such ways are often described as cognitive tools" (Lajoie & Derry, 1993, p. 32), and more research is now showing the benefits to be derived from such applications. Cognitive tools describe such applications as (a) calculators, (b) databases, (c) spreadsheets, (d) communications software, (e) semantic network tools, and (f) knowledge construction tools. The critical attribute of cognitive tools is not in the information and knowledge that they carry, but the forms of learner activity and engagement that they support and encourage. Cognitive tools still need the informed teacher to design and supervise the learning activity, but they act to amplify and distribute the cognitive tasks through their design and application.

A study by Ryba and Brown (2000), conducted in two classrooms in an elementary school in New Zealand, found that teachers' beliefs about themselves and their roles in the classroom, as well as their philosophy of education had a central place in shaping the nature of their computer use. Those teachers who saw learner-centered classrooms and authentic learning tasks as central to the success of their students were more likely to use the technology on a continuing basis.

Means and Olson (1997) found that technology increased the complexity with which students could deal successfully and created a multiplicity of roles, leading to student specialization. It allowed in-depth exploration of a smaller number of ideas and related facts around authentic, challenging tasks. They further state:

> *"When students are using technology as a tool or a support for communicating with others, they are in an active role rather than the passive role of recipient of information transmitted by a teacher, textbook, or broadcast. The student is actively making choices about how to generate, obtain manipulate, or display information. (p. 125)"*

2.3.2 Learning from Technology: Behaviorist Perspective

Use of technology from the behaviorist perspective mirrors traditional classroom practice: users are relatively passive, the content and interaction between the user and the software are predetermined, and there is a limited repertoire of acceptable responses (Jonassen, 2000). The acquisition of facts through repeated practice and rote memory, or learning from the technology, is the goal of instruction (Jonassen & Reeves, 1996).

Computer assisted instruction (CAI), integrated learning systems, drill-practice programs, computer-based tutoring systems, and assessment software are some of the technologies designed based on the behaviorist learning theory (Jonassen, 2000). CAI and integrated learning systems have been readily adopted in many schools in the USA as they closely match the traditional routine of classroom life. Jonassen argues that CAI can increase achievement because it leads to automaticity of lower-level skills through extended practice. A computer that is endlessly patient with the learner monitors this practice. In the tutorial form of computer-assisted instruction, the computer provides additional information to the learner if an incorrect answer is supplied. This continues until the learner is successful. Skinner's views of immediate positive reinforcement following a correct answer are directly applicable to drill-and-practice and tutorial forms of CAI (Yaakub, 1998).

Technology integration from this perspective is commonly used to increase student motivation. In a study exploring differences in teachers` uses of technology and their perceptions of the value or role of technology, Ertmer, Addison, Lane, Ross, and Woods (1999) found that majority of the teachers in elementary schools in the USA perceived technology as an incentive or behavioral reward in order to motivate students to complete their assignments and make lessons more interesting to students. At the time of the study, the teachers in this study were using technology for drill-and-practice activities and as a presentation tool to support their lessons. Almost all uses observed by the researchers, as well as those described by the teachers, involved the application of some type of instructional game or informational CD-ROMs. The study revealed that their integration of technology was mainly related to its usage to employ computers as presentation tools providing additional resources and engaging visuals to enhance lessons, to motivate students and to promote the belief that students need to use technology to be prepared for the future.

2.4 Conceptual Framework (The TPCK Framework)

The Technological Pedagogical and Content Knowledge (TPCK) framework builds on Shulman's (1987, 1986) descriptions of PCK to describe how teachers' understanding of educational technologies and PCK interact with one another to produce effective teaching with technology. Other authors have discussed similar ideas, though often using different labeling schemes. The conception of TPCK described here has developed over time and through a series of

publications, with the most complete descriptions of the framework found in Mishra and Koehler (2006) and Koehler and Mishra (2008).

In this model (see Figure below), there are three main components of teachers' knowledge: content, pedagogy, and technology. Equally important to the model are the interactions between and among these bodies of knowledge, represented as PCK, TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPCK

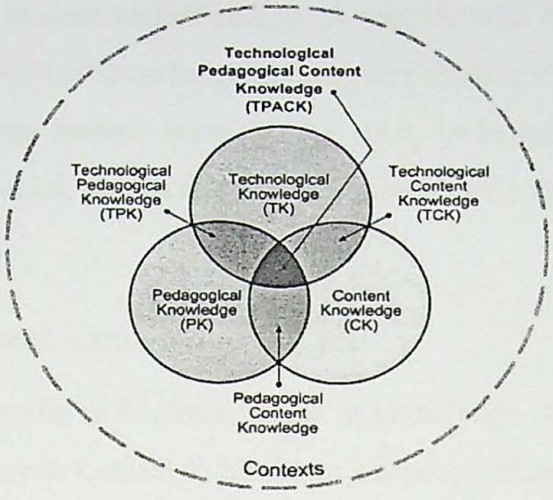


Fig 2. 1. The TPCK framework and its knowledge components

2.4.1 Content Knowledge (CK)

Content knowledge (CK) is teachers' knowledge about the subject matter to be learned or taught. The content to be covered in middle school science or history is different from the content to be covered in an undergraduate course on art appreciation or a graduate seminar on astrophysics. Knowledge of content is of critical importance for teachers. As Shulman (1986) noted, this knowledge would include knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches toward developing such knowledge. Knowledge and the nature of inquiry differ greatly between fields, and teachers should understand the deeper knowledge fundamentals of the disciplines in which they teach. In the case of science, for example, this would include knowledge of scientific facts and theories, the scientific method, and evidence-based reasoning. In the case of art appreciation, such knowledge would include knowledge of art history, famous paintings, sculptures, artists and their historical contexts, as well as knowledge of aesthetic and psychological theories for evaluating art.

2.4.2 Pedagogical Knowledge (PK)

Pedagogical knowledge (PK) is teachers' deep knowledge about the processes and practices or methods of teaching and learning. They encompass, among other things, overall educational purposes, values, and aims. This generic form of knowledge applies to understanding how students learn, general classroom management skills, lesson planning, and student assessment. It includes knowledge about techniques or methods used in the classroom; the nature of the target audience; and strategies for evaluating student understanding. A teacher with deep pedagogical knowledge understands how students construct knowledge and acquire skills and how they develop habits of mind and positive dispositions toward learning. As such, pedagogical knowledge requires an understanding of cognitive, social, and developmental theories of learning and how they apply to students in the classroom.

2.4.3 Pedagogical Content Knowledge (PCK)

PCK is consistent with and similar to Shulman's idea of knowledge of pedagogy that is applicable to the teaching of specific content. Central to Shulman's conceptualization of PCK is the notion of the transformation of the subject matter for teaching. Specifically, according to Shulman (1986), this transformation occurs as the teacher interprets the subject matter, finds multiple ways to represent it, and adapts and tailors the instructional materials to alternative conceptions and students' prior knowledge. PCK covers the core business of teaching, learning, curriculum, assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy. An awareness of common misconceptions and ways of looking at them, the importance of forging connections among different content-based ideas, students' prior knowledge, alternative teaching strategies, and the flexibility that comes from exploring alternative ways of looking at the same idea or problem are all essential for effective teaching.

2.4.4 Technology Knowledge (TK)

The definition of TK used in the TPCK framework is close to that of Fluency of Information Technology (FITness), as proposed by the Committee of Information Technology Literacy of the National Research Council (NRC, 1999). They argue that FITness goes beyond traditional notions of computer literacy to require that persons understand information technology broadly enough to apply it productively at work and in their everyday lives, to recognize when information

technology can assist or impede the achievement of a goal, and to continually adapt to changes in information technology. FITness, therefore, requires a deeper, more essential understanding and mastery of information technology for information processing, communication, and problem solving than does the traditional definition of computer literacy. Acquiring TK in this manner enables a person to accomplish a variety of different tasks using information technology and to develop different ways of accomplishing a given task. This conceptualization of TK does not posit an "end state," but rather sees it developmentally, as evolving over a lifetime of generative, open-ended interaction with technology.

2.4.5 Technological Content Knowledge (TCK)

TCK is an understanding of the manner in which technology and content influence and constrain one another. Teachers need to master more than the subject matter they teach; they must also have a deep understanding of the manner in which the subject matter (or the kinds of representations that can be constructed) can be changed by the application of particular technologies. Teachers need to understand which specific technologies are best suited for addressing subject-matter learning in their domains and how the content dictates or perhaps even changes the technology or vice versa.

2.4.6 Technological Pedagogical Knowledge (TPK)

TPK is an understanding of how teaching and learning can change when particular technologies are used in particular ways. This includes knowing the pedagogical affordances and constraints of a range of technological tools as they relate to disciplinarily and developmentally appropriate pedagogical designs and strategies. To build TPK, a deeper understanding of the constraints and affordances of technologies and the disciplinary contexts within which they function is needed.

2.4.7 Technology, Pedagogy, and Content Knowledge (TPCK)

TPCK is an emergent form of knowledge that goes beyond all three "core" components (content, pedagogy, and technology). Technological pedagogical content knowledge is an understanding that emerges from interactions among content, pedagogy, and technology knowledge. Underlying truly meaningful and deeply skilled teaching with technology, TPCK is different from knowledge of all three concepts individually. Instead, TPCK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes

concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones.

2.5 ICT Tools of Particular Relevance to Mathematics Education

An important aspect of being an informed technology-using teacher is to make decisions about the appropriateness of various technologies for use in the classroom. The following are a very few examples among the various technology tools to support the teaching of mathematics.

2.5.1. Spread Sheets

Spreadsheets such as *Excel* (http://office.microsoft.com/) are widely available on many personal computers. *Excel* have some strength in helping students learn algebra (Ex. Matrix), organize data, updating calculations and graphs as values(parameters) are changed. Isikal and Askar (2005) investigated the effect of spreadsheet and dynamic geometry software on mathematics achievement and Mathematics self-efficacy. The results indicate that using technology effectively as a learning tool improves students' mathematics achievement. Some scholars advocate *Excel* due to its widespread use in schools/industry and relatively easy access (Hunt 1996).

2.5.2 Calculators

Calculators, like any other technology, cannot replace basic understanding and intuitions in mathematics. This point is stated clearly in the following NCTM position statement (2005) on the place of computation, calculator and common sense in the mathematics classrooms as:

> *"School mathematics programs should provide students with a range of knowledge, skills, and tools. Students need an understanding of number and operations, including the use of computational procedures, estimation, mental mathematics, and the appropriate use of the calculator. A balanced mathematics program develops students' confidence and understanding of when and how to use these skills and tools. Students need to develop their basic mathematical understandings to solve problems both in and out of school."*

Hence, to encourage the use of calculators in the mathematics classrooms, the mathematics curriculum has to be modified to integrate calculators in a meaningful way while promoting mental computation, basic computational skills, estimation and problem solving. Perhaps the most portable tool and one that is being increasingly used in lower grade levels (in western culture) is the graphing calculator. A graphing calculator (Ex. Ti-83) is a learning tool designed to help students visualize and better understand concepts in mathematics, statistics and science (Dunham & Dick 1994). Advancements in technology have made the graphing calculator a powerful tool for analyzing and exploring data. Students also need to be wary that the output given by the graphing calculator is not sufficient communication of results. Ti-83 graphing calculator (hardware/software) is available through Texas Instruments.

2.5.3 Geometer's Sketchpad (GSP)

Sketchpad is a single, but general-purpose software program designed to let students begin doing real mathematics at any entry point.. It's a general-purpose tool that allows students of any age to do, explore, and share mathematics, just as a word processor allows them to write, edit, and share ideas. It is also an important exploratory tool for college-level mathematics, supported by activities in linear algebra, three dimensional modeling, dynamical systems, and non-Euclidean geometry. Research on technology integration in mathematics education has examined the effectiveness of dynamic geometry software on achievement (Isikal & Askar, 2005). Similarly, Sinclair (2004) found that using the Geometer's Sketchpad activities helps students notice geometric details, explore relationships and develop reasoning skills related to geometric proof. Geometer's Sketchpad software is available through Key Curriculum Press.

2.5.4 Fathom

Different kinds of educational software programs have been developed exclusively for helping students learn mathematics. *Fathom* (http://www.keypress.com/x5656.xml), a flexible and dynamic tool was designed with the input of many statistics educators and educational researchers to help students understand abstract concepts and processes in statistics, and does not attempt to have the capabilities of more traditional statistical software tools. Erickson (2002) described *Fathom* as a dynamic computer learning environment for teaching data analysis and statistics based on dragging, visualization, simulation, and networked collaboration. The strongest features of *Fathom* are the easy access to multiple, linked representations, including sliders, the ability to

build and run simulations, and the many different ways of importing data from a variety of sources. One small example of the very dynamic, interactive features of *Fathom* is pointing on the edge of a histogram bar and dragging the bar, which immediately updates the graph. Fathom software is available through Key Curriculum Press.

2.6 ICT development in Ethiopia

The importance the Government of Ethiopia has placed on education for national development is evident from the urgency with which the transitional government adopted the Education and Training Policy in 1994. The WoredaNet, the e-government communication backbone, developed by the Ethiopian Telecommunication Corporation, is a promise and a major enabler for rapid ICT development in the country. Already the public sector and the education sector have begun to benefit from this network, and the health and agriculture sectors have been lined up for the next phase. With all this and a corresponding ICT for education policy and implementation plan, Ethiopia is set to become a model ICT user on the continent. The infrastructure seems to be falling into place and the policies and strategies are already there. The challenge now is for the government to effectively co-ordinate the implementation of the strategy. "The ICT in Education Implementation Strategy and its corresponding Action Plan are components of a wider Ethiopian national e-education initiative" (Harry, 2007). This initiative forms one of the pillars of the ICT for Development 2010 Plan. The strategy is built on three main streams:

- Ethiopian National SchoolNet Initiative
- The National ICTs in Higher Education Initiative
- The National ICT Education, Training and Awareness Initiative

These three streams form the basis for the implementation of the strategy across the education sector. The National SchoolNet initiative, for instance, is aimed at the deployment and the exploitation of ICTs to facilitate the teaching and learning process within primary, secondary, technical and vocational schools. The ICTs in Higher Education Initiative focuses on deploying ICTs within the universities, colleges, and research institutions. And, finally, the National ICT Education, Training and Awareness initiative promotes ICT awareness and literacy, lifelong and adult education, and distance and virtual education and learning. The strategy also identifies strategic goals and draws up a program and activities for each initiative. Both the national ICT 4D

2010 Plan and the ICT in Education Implementation Strategy recognize ICT as an enabler for widening access to education for the Ethiopian population, for supporting literacy education, and for facilitating educational delivery and training at all levels.

2.6.1 WoredaNet Initiative

This is a major e-government initiative that connects all 600 of Ethiopia's local councils (*woredas*) to 11 regional capitals through Internet telephone and video-conferencing. .) Half the links are by cable, and half by satellite. The initiative also provides connectivity to the SchoolNet, eHealth, and the soon-to-be launched AgriNet. WoredaNet is implemented by the Ethiopia Telecommunication Agency with funding from the World Bank and the African Development Bank through the Ministry of Capacity Building.

2.6.2 SchoolNet Ethiopia

The joint initiative by the Ministry of Education and UNDP is probably the most visible project in the country with a total of 181 schools equipped with a minimum of 15 networked computers per lab all connected to the Internet.. There are new program around this initiative in the planning stages, including creating an extranet that will connect the schools.

2.7 Teacher Education Program and the Mathematics Curriculum in Ethiopia

The training strategy of teachers for general education system of Ethiopia emanates from the new education and training policy of the government, which was endorsed in 1994. In this policy document the following statements are worth mentioning in view of the subsequent interventions being taken.

> *"Ascertain that teacher trainees have the ability, diligence, professional interest and physical and mental fitness appropriate for the profession...Teacher education and training components will emphasize basic knowledge, professional code of ethics, methodology and practical training.*
>
> *Teachers will be certified before [being] assigned to teach at any level of education. The criteria for the professional development of teachers will be continuous education and training professional ethics and teaching performance...Teacher training institutions of all*

levels will be required to gear their program towards the appropriate educational level for which they train teachers. Special attention will be given to the participation of women, in the recruitment, training and assignment of teachers...." Education and training policy(1994,p20).

In light of the above quoted policy direction, the teacher training strategy and program have been developed and being implemented having laid several training objectives the major ones being:

- Prepare adequate number of qualified and competent teachers for all levels of the education system that both contribute to the quality of education and the overall social, cultural and economic growth of the country;
- Produce the kind of teachers which are able and competent to satisfy the secondary educational objectives stated in the education and training policy;

  "Strengthen the training system in such a way that the trainees acquire the required knowledge, and pedagogical skill for teaching general and major subject areas. In line with these assertions, the Ministry of Education along with the National Regional States Education Bureaus has quickly gone to prepare teachers to handle the new curricula. This involved the creation of new colleges and universities that specialize in the training of schoolteachers for both primary and secondary schools. Consequently, in addition to strengthening the previous faculties that cater for such program, there are now four additional Universities and Teacher Education Colleges that have secondary teacher training program."

On the view of these, as stated in the policy document, Mathematics is considered as a tool for other disciplines and the bases for content selection and organization is on the fact that this subject is not an end. Therefore, the approach adopted is to demonstrate this in its organization. In light of this, care was taken to ensure its contribution to understand and apply it in the learning of sciences and technical/vocational subjects. Furthermore, "the needs of the society are considered in order to provide students at each level with the appropriate [mathematical] knowledge, abilities and skills." Care was also taken "to make increasing use of mathematical means and methods to develop a better understanding and recognition of their environment (Ibid. 19).

Chapter Three: Research Design and Methodology

3.1 Introduction

This chapter addresses the design and methodology used in this study. A clear description of the research design and methodology, the study area and population, the subjects of the research, the sampling techniques and sample size, the data collection instruments, the validity and reliability of instruments and the methods of data analysis were discussed.

Concerning the design for this study, a quasi-experiment in general and the pretest-post-test non-equivalent group design in particular was used. A quasi-experimental design is one that looks a bit like an experimental design but lacks the key ingredient of random assignment. Quasi-experimental design involves selecting groups, upon which a variable is tested, without any random pre-selection processes. Quasi-experimental designs are meant to approximate all the advantages of true experimental designs as closely as possible implementing a program in a natural school setting.

The main distinction between experimental and quasi-experimental research lies in the allocation of subjects to groups. In true experimental research, subjects are allocated to groups through randomization to minimize bias. Quasi-experiments are often used precisely because such random allocation is not possible or practical. Typically, the experimental group is decided by which settings (e.g. schools, classrooms, factories), have volunteered or been selected to be part of the intervention. Therefore, rather than randomly allocating, I have chosen a control group that is as similar to the experimental group as possible. In order to retain the advantages of experimental designs (control over the environment) as much as possible, it is crucial to ensure that the experimental and comparison groups are as similar as possible. This was checked by using pretest. The notation for this design shows that there are two groups, an experimental and comparison group and that each is pretested before the program and post-tested after the treatment.

Intact group	Pretest observation	treatment	Post test observation
G1	O1	-	O2
G2	O1	X	O2

Table 3.1: The pretest-posttest non-equivalent group design

For this particular study it was assumed that G_1 are MNSR Group one students who did not receive experimental treatment (x), G_2 are MNSR Group two students who have received experimental treatment (x) and X is a treatment (technology) which is an independent variable in this study. The above decision of groups as comparison and treatment groups was made based on the analysis of the results of a pretest. (See Chapter 4)

3.2 Study Area and Population

The study was conducted at Arbaminch Teachers college abbreviated as AMCTE. AMCTE is one of the four teacher colleges in SNNP regional state established in 1981E.C. When it is first established, the main objective was to train teachers in certificate level who are capable of teaching grades one through four. After sixteen years of long journey, the College was upgraded to diploma level in 1997E.C. When it is upgraded to College level, the aim is to train middle class professionals in three years who can satisfy the needs of teachers in the region. Currently the college has six streams; namely Language stream, Mathematics and physical science stream, Natural science stream, Social science stream, professional studies stream, and Health and physical studies stream. Because, the focus of this research was a mathematics methodology, the study population consists of only mathematics and physical science stream students, particularly year one Mathematics and Natural Science Regular (MNSR) students. The reason behind selecting AMCTE as a study area was based on the researchers past experience in this college and sensing the existence of the problem under investigation.

There were 361 Regular mathematics students in year one through year three in mathematics stream which is divided in to two main streams; Math linear diploma program and Math cluster diploma programs. A linear diploma students are those who train Mathematics as their major and either physics or chemistry as their minor subject. But Mathematics cluster diploma students are those who take three subjects (math, chemistry and physics) as their major subjects. Both stays three years in the college and will be teaching on the same level after graduation. The following table shows the number of students in each stream.

Year	program	No. of students			Year of enrollment
		Male	Female	Total	
I	Linear	42	5	47	2010
	Cluster	68	19	87	
II	Linear	31	8	39	2009
	Cluster	65	9	74	
III	Linear	33	6	39	2008
	Cluster	65	10	75	
Total		304	57	361	

Table 3.2: First semester trainees' statistics in Mathematics stream in year 2011. Source: Mathematics dep't, AMCTE

3.3. Subjects and Sampling Procedures

The subjects of this study were first year regular Mathematics cluster diploma students ("Would be teachers") at Arba minch Teacher Education College (see above table). A purposive sampling method was employed in this study. According to Merriam (1998:12) purposive sampling is based on criteria determined by the researcher as to who is interviewed or which sites are observed. The main reason for selecting first year mathematics students was the following.

- First year students are free from practicum course for which they leave the college for school observations and block teaching which may intervene the experiment.
- The technologies that the researcher intends to introduce are compatible to the ongoing Mathematics course (Basic Mathematics II).

- ❖ As it is recommended by several experts in the area (Pringle, et al (2003), the use of technology should start as early as possible so that trainees would get more chance for practice and master the skill.

According to the first semester students' data above, the total number of trainees in cluster program was 87 which was further divided into two sections (MNSR group one and MNSR group two). There were 43 trainees in group one and 44 trainees in group two in semester I. But in second semester, the number of trainees in group one was diminished to 37 and that of group two was to 39 may be due to dismissal or withdrawal from the college. The researcher used these natural setting of classrooms as a comparison and experimental groups. The assignment of students in to experimental and comparison groups was made after comparing their pretest results. Based on that, section two was assigned as an experimental and the other section as a comparison group. The pretest result shows that the two groups (sections) were matching or alike. (See chapter 4).

3.4 Data Collection Instruments

3.4.1 Questionnaire

In order to get trainee's opinions on their prior pedagogy technology and content knowledge (PCK) a close ended questionnaire with a five point Likert scale ranging from strongly agree to strongly disagree was distributed to experimental group and data was obtained before the intervention. The total number of items in the first round questionnaire was 33. After the intervention, the same questionnaire with three additional items was administered to this group. The three items added were asking trainees to rate the use and relevance of technologies used to the teaching of Mathematics. The rating scales were excellent(5), very good(4), good(3), fair(2) and poor(1).The total number of items was 36. The questionnaire has seven integral components showing technology-classroom instruction linkages. These were Technology Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technology Pedagogy Content Knowledge (TPCK) components. Concerning the number of items in each component, there were five items of TK, two items of CK, eight items of PK, two items of PCK, two items of TCK, ten items of TPK, and four items of TPCK.

Here the purpose of collecting data through questionnaire from experimental group was to examine whether an intervention affected their prior PCK and thereby to check the significance of difference between the pre-and-post responses on the integration of technology with mathematics instruction. Thirty five questionnaires were distributed in the first round and thirty questionnaires (85.71%) were collected back. In the second round also the same numbers of questionnaires were distributed and 31(88.57%) questionnaires were collected back out of which 3 questionnaires were not responded correctly and hence rejected from analysis. Therefore, 28 questionnaires were responded correctly. Since the purpose of the questionnaire was to compare the responses of trainees in two rounds, the number of questionnaire respondents must be equal. Therefore, twenty eight questionnaires responded correctly in both rounds were compared and statistical decisions were made.

3.4.2 Pre-test and Post-Test

To examine the level of trainees' previous Mathematics achievement the groups' first semester Math 101(basic mathematics I) result was collected from Mathematics department and the groups were identified as high, medium and low achievers. To do this, the trainees' result from 100% was arranged in order and the first 27% of the distribution (upper class) was taken as High Level of achievement, the last 27% of the data set (lower class) was taken as low level and the rest 46% were taken as the medium achievement Level. This was done by checking the normality of the distribution of data.

After identifying the trainees' previous achievement level, a pre-test was prepared and administered to both groups. The test was prepared on the course basic Mathematics I(Math 101) which was given in Semester one. Twenty questions;10 true/false, 10 multiple choice items(See appendix A) were administered to MNSR G1 and MNSR G2 trainees before any treatment. After comparing the mean of the two groups, it was found that the groups were matching (There is no significant mean difference of scores between the two groups.) After this, MNSR G1 was assigned as comparison group and MNSR G2 as experimental group.

After identifying the experimental and control groups, a six weeks lesson (6x4hrs/week=24 lessons) was taught for both groups (with the help of technology for experimental and traditional lecture method for comparison group) and then both groups were post-tasted. The instructional technologies incorporated to the treatment groups were, TI-83 graphing calculator, Geometry

sketch pad 5.0 and Fathom 2.1. Concerning lesson delivery, the content taught was trigonometry which is chapter four of the ongoing course, math 102 for year one. A lesson plan was prepared for each lesson and commented by the college mathematics teachers and by the department head prior to the class. Concerning the classroom atmosphere, MNSR G1 students has been taught in their previous class (Room #01) with only blackboard hanged on the wall for the instructor's use. Generally speaking, it is a good model of traditional classroom that all students turned their faces towards the blackboard and the teacher acting on the stage.

On the other hand, the lesson was delivered to the experimental group (MNSR G2) in a more interactive and conducive classroom atmosphere. The classroom used for this group was the college's ICT room with very good facility. Some of these facilities and resources available in this classroom were one computer for every two students, An LCD with a projector, white board and markers. In addition to these resources the researcher used his own Laptop to display activities and guide lines and procedures in how to use the software. The softwares were installed to each computer and every student had a chance to work at least in pairs. The role of the teacher (the researcher in this case) was a facilitator's role and students were active participants on the lesson.

After six weeks of lesson delivery, a post test was prepared and administered to examine whether the treatment had an effect on students' Mathematics achievement or not. A total of 20 questions; 10 true false, 10 multiple choice items (See appendix B) were administered. It was prepared based on the course' syllabus and course objectives (See appendix D) of the lessons taught. In this case 36 trainees in G1 and 38 trainees in G2 were post tested. One trainee from each group (total two) did not take the posttest due to unknown reason.

The content area, the time required and the type of technology induced during the six weeks lesson (after a pre-test) are given in the table below.

Time	Subject area	Contents	Technology
6 weeks (6x4hrs/week= 24)	Chapter IV Trigonometric functions	4.1. The six trigonometric functions and their properties 4.2. Graphs of trigonometric functions 4.3. Trigonometric identities 4.4. Double angle and half angle formulas 4.5. Solving triangles 4.6. Angle of elevation and angle of depression	GSP 5.1 software TI-83 graphing calculator Fathom 2.1 software LCD, Projector and computer

Table 3.3: Content areas and a type of technology integrated during the treatment

- Sample lesson plans are attached at the appendix part.(See Appendix G)

3.5 Validity and Reliability of Instruments

Item analysis is a post administration examination of a test (Remmers, Gage and Rummel, 1967: 267). The quality of a test depends upon the individual items of a test (Freeman, 1962:113, Shrama, 2000: 197). Item analysis helps to find out how difficult the test item (Gronlund, 1993: 103). Item analysis further helps to detect specific technical flaws and thus provide further information for improving test items (Gronlund, 1993: 102). Similarly, it helps in selecting the best items for the final test, reject poor items and modify some of the items (Sharma, 2000:107). The item analysis procedure provides following information on each item.

Based on the above views, the researcher prepared a pretest and posttest based on the college mathematics syllabus/ course module. In developing the test items, the researcher first prepared a table of specification (See Appendix D) based on the objectives and contents of the course material in collaboration with the college teacher who previously offered the course. Moreover, the researcher overviewed the trigonometry tests which were prepared previously (from question bank) so as to see the kind of a test to be prepared. The first draft of both the pretest and posttest was piloted in Mathematics and natural science first year linear diploma program trainees with 40 students and item analysis was made in order to determine the validity and reliability of the test

items. With this regard, 5 items in pretest and 7 items in posttest were rejected after the pilot test by reducing the total number of the actual items administered to 20 in both cases.

3.5.1 The Difficulty Level of the Items

The percentage of students who answer test items correctly in a test is called difficulty level of an item (Gronlund, 1993: 103). In other words, the difficulty level of item is defined as the proportion or percentage of the examinees or individuals who answered the items correctly (Singh, 1986: and Remmers, Gage and Rummel, 1967: 268). According to Frank S. Freeman "the difficulty value of an item may be defined as the proportion of certain sample of subjects who actually know the answer of an item" (cited in Sharma, 200:200). The difficulty of an item can be determined in several ways (Garret, 1981: 362-363):

The level of difficulty is represented by a numerical term, which may range from 0 to 100 percent (Remmers, Gage and Rummel, 1967: 268). A general rule of measurement of any item whose difficulty index is lower than 10 or higher than 90 is worthless measurement (Remmers, Gage and Rummel, 1967: 268). Since, difficulty refers to the percentage answering the item correctly, the smaller the percentage figures the more difficulty the item (Gronlund, 1993: 103). Thus if item is correctly answered by 90 percent of examinees, they are regarded easy whereas those items are difficult if they are correctly answered only by 5 percent of examinees. So, an items answered correctly by 100% or 0% examinees have no differentiating significance. (See appendix E and F) for the difficulty level and discriminating power of the items in pretest and posttest in this study)

3.5.2The Discriminating Power of the Items

According to Marshall Hales (1972) the discriminating power of the item may be defined as the extent to which success or failure on that item indicates the possession of the achievement being measured. In other words, the ability of the test items measures the better and poorer examinees of items (Remmers, Gage and Rummel, 1967: 268). The discriminating power is defined in the numerical term, which may range from +1 to –1(Remmers, Gage and Rummel, 1967: 268). On the basis of discriminating power, items are classified into three types (Sharma, 2000: 201).

- **Positive Discrimination**: If an item is answered correctly by superiors (upper groups) and but not answered correctly by inferiors (lower group) such item possess positive discrimination.

- **Negative Discrimination**: An item answered correctly by inferiors (lower group) but not answered correctly by the superiors (upper groups) such item possesses negative discrimination.
- **Zero Discrimination:** If an item is answered correctly by the same number of superiors as well as inferiors examinees of the same group. The item cannot discriminate between superior and inferior examinees. Thus, the discrimination power of the item is zero.

The steps, which were used for item analysis, in the present study, propounded by Gronlund, (1993: 103) and Ebel and Frisbie(1991:225) are present below

- All test papers were first orderly arranged from highest to the lowest score.

- Sum the numbers of examinees who give the correct responses and these numbers was divided the total number of examinees and multiply by 100 for each item. The result as percentage is the index of difficulty or P-value.

- 27% papers were selected with the highest scores and called this the upper group. Similarly, 27% papers were selected with the lowest scores, which were called the lower group.

- For each item, number of examinees who gave correct response in the upper groups was counted. The same was done in lower group. Subtract the lower group counts from the upper group count for the correct responses. Divide this difference by the number of examinees in one of the group (either upper or lower group both are in same size). The expressed result as a decimal is the index of discrimination or D- value. (See appendix E and F for the discrimination power of the items in this study)

3.5.3 Reliability Coefficient for Internal Consistency

There are several statistical indexes that may be used to measure the amount of internal consistency for an exam. The most popular index (and the one reported in Testing & Evaluation's item analysis) is referred to as Cronbach's alpha. Cronbach's alpha provides a measure of the extent to which the items on a test, each of which could be thought of as a mini-test, provide consistent information with regard to students' mastery of the domain. In this way, Cronbach's alpha is often considered a measure of item homogeneity; i.e., large alpha values indicate that the items are tapping a common domain.

Cronbach's alpha ranges from 0 to 1.00, with values close to 1.00 indicating high consistency. Professionally developed high-stakes standardized tests should have internal consistency coefficients of at least 0.90. Lower-stakes standardized tests should have internal consistencies of at least 0.80 or 0.85. For a classroom exam, it is desirable to have a reliability coefficient of 0.70 or higher.

In this study, Cronbach's alpha was used to determine the reliability of both a pretest and a posttest. α for a pretest was found to be 0.86 and α for a posttest was 0.78 which is acceptable level of α(See Appendix E and F).

Similarly, a pilot study for the questionnaire was carried out in Mathematics and natural science Group 1 trainee's with28 trainees. Based on the results of analysis the reliability coefficient (Cronbach's alpha) was found to be 0.67 which is an acceptable level.

3.6 Methods of Data Analysis

Data analysis is the process of making sense of the data by consolidating, reducing and interpreting verbal accounts, observation and information from documents (Merriam, 1998:178). Patton (1987:144) also writes "analysis is the process of bringing order to the data, organizing what there is into patterns and basic descriptive units".

Depending on the nature of the basic research questions (hypothesis) and the data collected, different statistical techniques were used for analyzing the research questions (to test the hypothesis). The two hypotheses to be tested in this study were the following.

1. There is no mean difference between the pre-test and post-test scores of trainees who learned mathematics with technology and without a technology with respected to gender and achievement level.
2. There is no difference on the trainees' Pedagogy Content Knowledge (PCK) who learned mathematics with technology and without a technology.

In this study, Paired sample t-test, independent sample t-test, one-way ANOVA and ANCOVA were used as a means to analyze data. The level of significance (α-level) used in this study was 0.05 (95% confidence interval). To make the statistical discussion whether a test result is statistically significant or not, an effect size measure for two independent groups was made.

Cohen (1988) defined *d* as the difference between the means, M1 - M2, divided by the pooled standard deviation, σ, of either group. Cohen argued that the standard deviation of either group could be used when the variances of the two groups are homogeneous. In meta-analysis the two groups are considered to be the experimental and control groups.

$d = \frac{M_1 - M_2}{\sigma}$ where $\sigma = \sqrt{[\frac{(X-M)^2}{N}]}$, where X is the raw score, M is the mean, and N is the number of cases.

The pooled standard deviation is found as the root mean square of the two standard deviations (Cohen, 1988, p.44). That is, the pooled standard deviation is the square root of the average of the squared standard deviations. When the two standard deviations are similar the root mean square will be not differ much from the simple average of the two variances.

$d = \frac{M_1 = M_2}{\sigma_{Pooled}}$ and $\sigma_{pooled} = \sqrt{[\frac{(\sigma_1^{\ 2} + \sigma_2^{\ 2})}{2}]}$

d can also be computed from the value of the *t*- test of the differences between the two groups (Rosenthal and Rosnow, 1991) as:

$d = \frac{2t}{\sqrt{df}}$ or $d = \frac{t(n_1 + n_2)}{\sqrt{df}\sqrt{(n_1 n_2)}}$ where "df" is the degree of freedom for the *t* test and "n i's" are the number of cases for each group. The following is a recommended effect size by Cohen (1988, p. 25). 0.0-0.2 is a small, 0.3-0.5 medium, 0.6-0.8 large and 0.8 above is a very large effect size.

3.7 Ethical Considerations

During this study, all ethical issues were taken into considerations and all the necessary procedures were followed to make the finding of this research valid and reliable. After the approval of the proposal, the letter of concern written from the office of Natural Science Education Unit, Addis Ababa University was submitted to AMCTE and explained all the aims and objectives of this study to the concerned bodies of the college. After getting permission from the college administration,

awareness about the study was made with the subjects (trainees of first year Mathematics and natural science stream) to make them an informed consent. To collecting all the necessary data it required eight weeks.

Chapter Four: Data Presentation, Analysis and Discussion

4.1 Introduction

This chapter presents the analysis and interpretation of the data collected through different tools. In analyzing and interpreting the collected data a quantitative method of data analysis was employed. The data were organized in tables and analyzed in line with the basic research hypothesis. The main purpose of this study was to investigate the effect of integrating instructional technology into Mathematics classroom on trainees' Pedagogical Content Knowledge. The chapter also discusses the major characteristics and background of the student-teachers who have been involved in filling the questionnaire and in the pre-post-tests.

4.2 Presentation and Analysis of Data Through Questionnaire

4.2.1 General Characteristics of Questionnaire Respondents

The respondents of the questionnaire were MNSR G2 trainees (the experimental group) only. This group filled the same questionnaire twice (some three additional items on the second) before and after the intervention to see whether the treatment had an effect on their PCK or not. The following data shows the general characteristics of 28 trainees who responded correctly to the questionnaire.

Group	Characteristics of Respondents		
MNSR G2 (Exp.Group)	Sex	Number	%
	Male	23	82.14
	Female	5	17.86
	Age		
	15-20	17	60.71
	21-25	11	39.29
	26-30	0	0
	Above 30	0	0

Table 4.1 Characteristics of questionnaire respondents

As table 4.1 shows, 23 (82.14%) of the trainees responded were males and the rest 5 (17.86%) were females. Based on the demographic questions asked to identify the age of the trainees, 17(60.71%) of the respondents were in between age15-20, 11(39.29%) were in between 21-25 and no student-teachers above the age 26 in the group. From this we see that most of the trainees' age lies in between 15-20 year.

In this section the first hypothesis of the study was tested. The hypothesis was the following.

Hypothesis 1: There is no significant difference on the trainee's Pedagogy Content Knowledge (PCK) who learned mathematics with technology and without a technology.

Based on the above hypothesis, the trainees' response to the questionnaire based on the five point Likert scale was summarized and analyzed. To check the significance of a difference between trainees opinions before and after the intervention, a chi-square test of independence (χ^2) was used as a statistical tool. A non parametric (χ2-median) test was used because Likert scales fall within the ordinal level of measurement. i.e, the response categories have a rank order (S. Jamieson, 2004; 38). The questionnaire was composed of the seven integral components of teachers' technology pedagogy content knowledge (TPCK) framework. These were Technology Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technology Pedagogy Content Knowledge (TPCK) . Concerning the number of items in each component, there were five items of TK, two items of CK, eight items of PK, two items of PCK, two items of TCK, ten items of TPK, and four items of TPCK. To test the above hypothesis a specific sub-hypothesis was formulated as follows.

H_0: There is no relation between integrating technology and trainees' PCK.

H_1: There is a relation between integrating technology and trainees' PCK.

Now the data analysis for each components of TPCK is as follows.

1. Trainees' Responses to Technology Knowledge (TK) Items

There were five items under Technology Knowledge (TK) on the questionnaire. The following table shows the items and the values of their corresponding chi-square test of independence.

Item No.	**Technology Knowledge(TK)**	χ^2	df	p-value
1	I know a lot about different instructional technologies	45.54	4	0.00
2	I have the technical skills needed to use classroom technology	48.00	4	0.00
3	I can learn technology easily	21.79	4	0.00
4	I frequently play around the technology	17.32	4	0.002
5	I have had sufficient opportunities to work with different technologies	21.04	4	0.00

$\chi^2_{cri} = 9.48 \quad \alpha=0.05 \quad df= 4$

Table 4.2 TK items and their chi-square test of independence

Table 4.2 shows the five items under TK category and their corresponding value of chi-square, the degree of freedom and the level of significance (P) value for the difference of medians between the pre-and-post-response to the questionnaire. The following table shows the basic descriptive statistic of the pre-and-post response of trainees for the above five questions.

Report

PCKquestionnaire		pckq1	pckq2	pckq3	pckq4	pckq5
pre-responce-pck	Median	3.0000	2.0000	3.5000	3.0000	1.0000
	Mean	2.5357	1.8571	3.1786	2.8571	1.3929
	Std. Deviation	.79266	.75593	.98333	1.17739	.49735
	Std. Error of Mean	.14980	.14286	.18583	.22251	.09399
post-response-pck	Median	5.0000	4.0000	4.0000	4.0000	2.0000
	Mean	4.4643	4.2857	4.3214	4.0714	2.5357
	Std. Deviation	.69293	.65868	.54796	.94000	1.03574
	Std. Error of Mean	.13095	.12448	.10356	.17764	.19574
Total	Median	4.0000	3.0000	4.0000	4.0000	2.0000
	Mean	3.5000	3.0714	3.7500	3.4643	1.9643
	Std. Deviation	1.22103	1.41238	.97701	1.22050	.99021
	Std. Error of Mean	.16317	.18874	.13056	.16310	.13232

Table 4.3.Discriptive statistics of trainees' responses on TK component

As table 4.3 shows for the question asking trainees' knowledge about different instructional technologies, the median of a pre-response is 3.0(undecided) whereas that of the post-response is 5.0(strongly agree). As one can see, there is a difference between the degrees of decision to the same item before and after the treatment. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 45.45$ with ($p=0.00<0.05$, df=4). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. This implies that trainees came to know different instructional technologies after the treatment was employed.

In the same way, for the question asking trainees whether they have the technical skills needed to use classroom technology or not, the median of a pre-response is 2.0(disagree) whereas that of the post-response is 4.0(agree). As one can clearly see from this, there is a difference between the degrees of agreement for pre-and-post response of the same item. To test whether this difference is significant or not, a chi-square test for independence was used and is $\chi^2 = 48.0$ with ($p=0.00<0.05$, df=4). The test confirms that there is statistically significant difference among the two medians supporting the alternative hypothesis. Hence, from this result it could be conclude that trainees have got better technical skills need to use a classroom technology after the treatment was undertaken.

Similarly, for the question asking trainees about the way they learn technology, the median of a pre-response is 3.5(between agree and undecided) whereas that of the post-response is 4.0(agree).

There is a difference on the degrees of decision between the pre-and-post responses to the same item. To test whether this difference is significant or not, a chi-square test was employed and found to be $\chi^2 = 21.79$ with ($p=0.00<0.05$, $df=4$). This test indicates that there is a statistically significant difference on the degrees of agreement supporting the alternative hypothesis. From this it could be said that, the attitude of trainees to learn technology was significantly changed after the treatment.

Likewise for the question asking trainees about their interest on technology, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. As one can see there is a difference between the pre-and-post decisions to the same question. To examine whether the difference is significant or not, a chi-square test is checked and found to be $\chi^2 = 17.32$ with ($p=0.02<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two median scores supporting the alternative hypothesis. Here, the result leads to conclude that trainees got a better opportunity of using instructional technology during the treatment period.

Finally, for the question asking trainees whether they have had sufficient opportunities to work with different technologies or not, the median of a pre-response is 1.0(strongly disagree) whereas that of the post-response is 2.0. It is clear from this that, the degree of decision made before and after the treatment both falls on the negative side of TK. To check whether this difference is significant or not, a chi-square test is $\chi^2 = 21.04$ with ($p=0.00<0.05$, $df=4$). The chi-square test indicates that there is still statistically significant difference among the two median scores supporting the alternative hypothesis. When critically examined, this result may indicate that trainees did not get better opportunities to use/learn through technology before the treatment or still they did not get satisfaction during the intervention may be due to the shortage of time they had during the treatment. Therefore, this result leads to re-examine the factor why trainees respond negatively to this question was left open for further investigation. According to Pringle et al. (2003) Prospective teachers who engage technology as a teaching tool develop new perspectives on using technology in their teaching which goes in line with the above findings.

2. Trainees' Responses to Content Knowledge (CK) Items

There were only two items under Technology Knowledge (TK) on the questionnaire. The following table shows the items and the values of their corresponding chi-square test of significance.

Item No.	Content Knowledge (CK)	χ^2	df	p-value
6	I know about various examples of how mathematics applies in the real world	20.98	4	0.00
7	I have various ways and strategies of developing my understanding of mathematics	26.11	4	0.00

$\chi^2_{cri} = 9.48$ $\alpha=0.05$ $df= 4$

Table 4.4 CK items and their chi-square test of independence

Table 4.4 shows, the two items under CK and their corresponding value of chi-square, the degree of freedom and the value of significance level (P) for the difference of medians between the pre-and-post-responses. The following table shows the basic statistic of trainees' pre-and-posttest responses to the content knowledge category items.

Report

PCKquestionnaire		pckq6	pckq7
pre-responce-pck	Median	2.0000	2.0000
	Mean	2.6429	2.3214
	Std. Deviation	1.19301	1.30678
	Std. Error of Mean	.22546	.24696
post-response-pck	Median	4.0000	4.0000
	Mean	4.2143	4.2500
	Std. Deviation	.91721	.75154
	Std. Error of Mean	.17334	.14203
Total	Median	4.0000	4.0000
	Mean	3.4286	3.2857
	Std. Deviation	1.31919	1.43608
	Std. Error of Mean	.17628	.19190

Table 4.5 Descriptive statistics of trainees' responses on CK component

As table 4.5 shows, for the question asking trainees about the application of mathematics in the real world, the median of a pre-response is 2.0(undecided) whereas that of the post-response is 4.0(agree). As one can see, there is a difference between the degrees of decision to the same item

before and after a treatment. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 20.98$ with ($p=0.00<0.05$, $df=4$). This test indicates that there is statistically significant difference among the two medians (degrees of agreement) supporting the alternative hypothesis. This result shows that trainees came to understand the application of mathematics in the real world very well after learning mathematics through technology.

Similarly for the question asking trainees about the ways and strategies of developing their understanding of mathematics, the median of a pre-response is 2.0(disagree) whereas that of the post-response is 4.0(agree) indicating a difference between the pre-and-post decisions to the same item. A test for independence assures that there is significant difference between the two median values with $\chi^2 = 26.11$ and $p=0.00<0.05$,($df=4$) supporting the alternative hypothesis. From this result it is apparent to conclude that trainees get to know the various ways and strategies to understand mathematics after the treatment was undergone. Ertmer, Addison, Lane, Ross, and Woods (1999) state that "teachers, not technology, hold the key to achieving integrated technology use," while Haughland (2000) states that how computers are used is more important than if computers are used. Therefore, from all the above evidences it would be reasonable to forward that integrating technology with mathematics has some relation to the trainees 'content knowledge (CK).

3. Trainees' Responses to Pedagogical Knowledge (PK) Items

There were eight items under Pedagogical Knowledge (PK) of the questionnaire. The following table shows the items and the values of their corresponding chi-square test of significance.

Item No.	Pedagogical Knowledge (PK)	χ^2	df	p-value
8	I can use a wide range of teaching approaches in a classroom setting (collaborative learning, direct instruction, inquiry learning, problem/project based learning etc.)	26.85	4	0.00
9	I can adopt my teaching style to different learners	23.33	4	0.00
10	I know how to assess student performance in a classroom	24.98	4	0.00
11	I am familiar with common student understandings and misconceptions	19.79	4	0.001
12	I can adopt my teaching based-upon what students currently understand or do not understand	22.99	4	0.00
13	I know how to organize and maintain classroom management	20.63	4	0.00
14	I have an understanding of how students learn	19.34	4	0.01
15	I can structure a lesson to promote student learning	22.31	4	0.00

$\chi^2_{cri} = 9.48$ $\alpha=0.05$ $df= 4$

Table 4.6 PK items and their chi-square test of independence

The above table shows, the eight items under PK and their corresponding value of chi-square, the degree of freedom and the value of significance level (P) for the difference of medians between the

pre-and-post-responses. The following table shows the descriptive statistics of trainees' responses on the pedagogy knowledge.

Report

PCKquestionnair		pckq8	pckq9	pckq10	pckq11	pckq12	pckq13	pckq14	pckq15
pre-responce-pcl	Median	2.0000	3.0000	2.0000	2.0000	3.0000	1.0000	3.0000	2.0000
	Mean	2.5000	2.7143	1.9643	2.0714	2.8214	1.6071	2.7500	1.7857
	Std. Deviation	1.07152	1.21281	.92224	.81325	1.36228	.78595	1.14261	.91721
	Std. Error of Me	.20250	.22920	.17429	.15369	.25745	.14853	.21593	.17334
post-response-pc	Median	4.0000	4.0000	4.0000	3.5000	5.0000	4.0000	4.0000	4.0000
	Mean	4.2143	4.2857	3.7500	3.3214	4.2143	3.2857	4.0357	3.5000
	Std. Deviation	.95674	.76290	1.20570	1.27812	1.06657	1.46204	1.03574	1.34715
	Std. Error of Me	.18081	.14417	.22786	.24154	.20156	.27630	.19574	.25459
Total	Median	3.5000	4.0000	2.5000	3.0000	4.0000	2.0000	4.0000	2.0000
	Mean	3.3571	3.5000	2.8571	2.6964	3.5179	2.4464	3.3929	2.6429
	Std. Deviation	1.32704	1.27920	1.39386	1.23465	1.40118	1.43868	1.26028	1.43246
	Std. Error of Me	.17733	.17094	.18626	.16499	.18724	.19225	.16841	.19142

Table 4.7 Descriptive statistics of trainees' responses on PK component

As table 4.7 above shows for the item asking trainees whether they could use a wide range of teaching approaches in a classroom setting or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. As one can see, there is a difference between the degrees of decision to the same item before and after a treatment. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 26.85$ with ($p=0.00<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Therefore, this result leads to conclude that trainees realized a wide range of teaching approaches in a classroom setting after the treatment was employed. Similarly, for the question asking trainees whether they could adopt their teaching style to different learners or not, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. There is a difference between the pre-and-post decisions to the same item. To test the significance of this difference a chi-square test for independence was computed and found $\chi^2 = 23.33$ with ($p=0.00<0.05$, $df=4$). The test confirms that there is statistically significant difference among the two medians supporting the alternative hypothesis. This result implies that trainees have learned the methods how to adopt their teaching style to different learners in the classroom after the experimental treatment.

In the same way, for the question asking trainees whether they know how to asses students' performance in a classroom or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 24.98$ with ($p=0.00<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Hence this result shows that trainees have got some idea about assessment and evaluating students' performance after the experiment was undergone.

Likewise for the question asking trainees whether they are familiar with common student understandings and misconceptions or not, the median of a pre-response is 2 whereas that of the post-response is 3.5. There is a difference between the pre-and-post medians to the same item. To see whether the difference is significant or not, a chi-square test for independence shows $\chi^2 = 19.79$with ($p=0.01<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Here it could be said that, trainees identified some of their common misconceptions about instructional technology due to the effect of the treatment.

The table also shows that, for the question asking trainees whether they could adopt their teaching based-upon what students currently understand or do not understand or not, the median of a pre-response is 3.0 whereas that of the post-response is 5.0. It is clear from this that, the degree of decision made before and after the treatment both falls on the negative side of TK. To check whether this difference is significant or not, a chi-square test is $\chi^2 = 22.99$with ($p=0.00<0.05$, $df=4$). The chi-square test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. From this it clear that the trainees come to know some important classroom conditions to proceed in the same way or to modify a lesson depending on the status quo of their learners.

As the table also indicates for the question asking trainees how to organize and maintain classroom management, the median of a pre-response is 1.0 whereas that of the post-response is 4.0. As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 20.63$ with ($p=0.00<0.05$, $df=4$). This test indicates that there is a

statistically significant difference among the two medians supporting the alternative hypothesis. This indicates that, trainees developed better skills how to organize and maintain classroom management as the result of an experimental treatment.

The table also shows that for the question asking trainees about their understanding of how students learn, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 19.34$ with ($p=0.01<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. As the result of this, it is reasonable to forward that trainees developed better understanding of how learning takes place.

Finally, for the question asking trainees whether they could structure a lesson to promote student learning or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0(agree). As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 22.31$with ($p=0.00<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Here it could be said that, the trainees come to learn how to structure a lesson to promote student learning. Means and Olson (1997) found that technology increased the complexity with which students could deal successfully and created a multiplicity of roles, leading to student specialization. It allowed in-depth exploration of a smaller number of ideas and related facts around authentic and challenging tasks. This indicates when students are using technology as a tool or as a support for learning they are in an active role of making choices about how to generate, obtain, manipulate, or display information. Hence, from all the above results and discussions it would be apparent to comment that integrating technology with mathematics lessons has some positive relationship with trainees' pedagogy knowledge.

4. Trainees' Responses to Pedagogical Content Knowledge (PCK) Items

There were two items under Pedagogical Content Knowledge (PCK) of the questionnaire.

Item No.	Pedagogical Content Knowledge (PCK)	χ^2	df	p-value
16	I know that different mathematical concepts require different teaching approaches	9.81	4	0.044
17	I know how to select effective teaching approaches to guide student thinking and learning in mathematics	18.11	4	0.001

$\chi^2_{cri} = 9.48$ $\alpha=0.05$ $df= 4$

Table 4.8 PCK items and their chi-square test of independence

Table 4.8 shows, the two items under PCK category of the trainees questionnaire and their corresponding value of chi-square, the degree of freedom and the value of significance level (P) for the difference of medians between the pre-and-post-responses. The following table shows the descriptive statistics of trainees' responses on the pedagogy content knowledge.

Report

PCKquestionnaire		pckq16	pckq17
pre-responce-pck	Median	3.5000	3.0000
	Mean	3.1786	3.0357
	Std. Deviation	1.18801	1.03574
	Std. Error of Mean	.22451	.19574
post-response-pck	Median	4.0000	4.0000
	Mean	4.0714	4.0357
	Std. Deviation	1.11981	1.03574
	Std. Error of Mean	.21162	.19574
Total	Median	4.0000	4.0000
	Mean	3.6250	3.5357
	Std. Deviation	1.22938	1.14359
	Std. Error of Mean	.16428	.15282

Table 4.9 Descriptive statistics of trainees' responses on PCK component

Based on the table 4.9, for the question asking trainees whether they know that different mathematical concepts require different teaching approaches or not, the median of a pre-response is 3.5 whereas that of the post-response is 4.0. As one can see, there is a difference between the degrees of decision to the same item before and after a treatment. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 9.81$ with ($p=0.044<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Therefore, this result shows that trainees realized that different mathematical concepts require different teaching approaches after the treatment.

In the same way, for the question that asks trainees whether they know how to select effective teaching approaches to guide student thinking and learning in mathematics or not, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. As one can clearly see from this, there is a difference between the pre-and-post decisions to the same item. To test whether this difference is significant or not, a chi-square test for independence was used and is $\chi^2 = 18.11$ with ($p=0.01<0.05$, $df=4$). The test confirms that there is a statistically significant difference among the two medians supporting the alternative hypothesis. This result implies that trainees came to understand the relationship which exists between pedagogy and content after they learn with a technology during the treatment period.

5. Trainees' responses to technological content knowledge (TCK) items

There were two items under Technological Content Knowledge (TCK) of the questionnaire

Item No.	**Technological Content Knowledge (TCK)**	χ^2	df	p-value
18	I know about technologies that I can use for understanding and doing mathematics	25.33	4	0.00
19	Using technology can fundamentally change the way people understand mathematics concepts	15.45	4	0.004

$\chi^2_{cri} = 9.48$ $\alpha=0.05$ $df= 4$

Table 4.10 TCK items and their chi-square test of independence

The above table shows, the eight items under TCK and their corresponding value of chi-square, the degree of freedom and the value of significance level (P) for the difference of medians between the pre-and-post-responses. The following table shows the descriptive statistics of trainees' responses on the technology content knowledge.

Report

PCKquestionnaire		pckq18	pckq19
pre-responce-pck	Median	2.0000	1.5000
	Mean	2.3929	1.7857
	Std. Deviation	1.34272	1.03126
	Std. Error of Mean	.25375	.19489
post-response-pck	Median	4.0000	4.0000
	Mean	3.8929	3.2143
	Std. Deviation	1.25725	1.54817
	Std. Error of Mean	.23760	.29258
Total	Median	4.0000	2.0000
	Mean	3.1429	2.5000
	Std. Deviation	1.49458	1.48936
	Std. Error of Mean	.19972	.19902

Table 4.11 Descriptive statistics of trainees' responses on TCK component

As table 4.11 shows, for the question asking trainees knowledge about technologies that they could use for understanding and doing mathematics, the median of a pre-response is 2.0 whereas that of the post-response is 4.0(agree). As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 25.33$with ($p=0.00<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Here the result indicates that trainees identified some technologies that could be used for understanding and doing mathematics after the treatment.

Similarly for the question asking trainees whether using technology can fundamentally change the way people understand mathematics concepts or not, the median of a pre-response is 1.5 whereas that of the post-response is 4.0. There is a difference between the pre-and-post medians to the same item. To see whether the difference is significant or not, a chi-square test for independence shows $\chi^2 = 15.45$with ($p=0.04<0.05$, $df=4$). This test indicates that there is a statistically significant

difference among the two medians supporting the alternative hypothesis. This result shows that trainees came to realize that using technology could have a power to change the way of understanding certain mathematical concepts.

6. Trainees' Responses to Technological Pedagogical Knowledge (TPK) Items

There were ten items under Technological Pedagogical Knowledge (TPK) of the questionnaire

Item No.	**Technological Pedagogical Knowledge (TPK)**	χ^2	df	p-value
20	I can adapt the use of the technologies that I am learning about to different teaching activities	29.19	4	0.00
21	I am thinking critically about how to use technology in my classroom	21.32	4	0.00
22	I have the classroom management skills to use technology appropriately in teaching	17.72	4	0.001
23	My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom	22.12	4	0.00
24	I can choose technologies that enhance students' learning for a lesson	12.17	4	0.16
25	Different teaching approaches require different technologies	15.39	4	0.04
26	I know how to use technology in problem/project-based learning	8.85	4	0.065
27	My teaching approaches change when I use technologies in a classroom	13.2	4	0.01
28	Knowing how to use a certain technology means that I can use it for teaching	15.22	4	0.004
29	Different technologies require different teaching approaches	20.38	4	0.00

$\chi^2_{cri} = 9.48 \quad \alpha=0.05 \quad df= 4$

Table 4.12 TPK items and their chi-square test of independence

Table 4.12 shows, the ten items under TPK and their corresponding value of chi-square, the degree of freedom and the value of significance level (P) for the difference of medians between the pre-and-post-responses. The following table shows the descriptive statistics of trainees' responses on the technology pedagogy knowledge.

Report

PCKquestionr		pckq20	pckq21	pckq22	pckq23	pckq24	pckq25	pckq26	pckq27	pckq28	pckq29
pre-responce-	Median	2.0000	3.0000	3.0000	2.0000	2.0000	3.0000	2.0000	3.0000	2.5000	2.0000
	Mean	2.5714	3.0000	2.7857	1.8571	2.0357	2.7857	2.5714	3.0000	2.5000	2.0357
	Std. Deviatio	.03382	.18634	.06657	.97046	.17006	.22798	.28894	.21716	.26198	.10494
	Std. Error of	.19537	.22420	.20156	.18340	.22112	.23207	.24359	.23002	.23849	.20881
post-response	Median	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
	Mean	4.3214	4.3214	3.9643	3.6071	3.3571	3.8571	3.5357	4.0714	3.4643	3.7143
	Std. Deviatio	.81892	.81892	.83808	.31485	.44566	.07890	.34666	.94000	.47779	.43649
	Std. Error of	.15476	.15476	.15838	.24848	.27320	.20389	.25449	.17764	.27928	.27147
Total	Median	4.0000	4.0000	4.0000	2.0000	2.0000	4.0000	3.5000	4.0000	3.0000	2.0000
	Mean	3.4464	3.6607	3.3750	2.7321	2.6964	3.3214	3.0536	3.5357	2.9821	2.8750
	Std. Deviatio	.27806	.21021	.12108	.44589	.46374	.26645	.39375	.20551	.44589	.52628
	Std. Error of	.17079	.16172	.14981	.19321	.19560	.16924	.18625	.16109	.19321	.20396

Table 4.13 Descriptive statistics of trainees' responses on TPK component

As table 4.13 shows for question that asks trainees whether they could adapt the use of the technologies that they are learning to different teaching activities or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. As one can see, there is a difference between the degrees of decision to the same item before and after a treatment. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 29.19$with ($p=0.00<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. This result leads to conclude that trainees realized how to adapt the use of the technologies that they have learned to different teaching activities.

For the question that asks trainees whether they think critically about how to use technology in their classroom or not, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. There is a difference between the pre-and-post decisions to the same item. To test the significance of this difference a chi-square test for independence was computed and found $\chi^2 = 21.32$with ($p=0.00<0.05$, $df=4$). The test confirms that there is statistically significant difference among the

two medians supporting the alternative hypothesis. From this result it is clear that trainees started thinking critically about how to use technology in their future classroom.

For the question that asks trainees whether they have classroom management skills to use technology appropriately in teaching or not, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 17.72$with ($p=0.001<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Here the result shows that, trainees have got classroom management skills to use technology appropriately in their teaching.

For the question asking trainees whether a teacher education program has caused them to think more deeply about how technology could influence the teaching approaches they use in their classroom or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. There is a difference between the pre-and-post medians to the same item. To see whether the difference is significant or not, a chi-square test for independence shows $\chi^2 = 22.12$ with ($p=0.00<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Here, the result indicate that trainees believe that the teacher education program caused them to think more deeply about how technology could influence the teaching approaches they would use in their future classroom.

For the question asks trainees whether they could choose technologies that enhance students' learning for a lesson or not, the median of a pre-response is 2.0(strongly disagree) whereas that of the post-response is 4.0. It is clear from this that, the degree of decision made before and after the treatment both falls on the negative side of TK. To check whether this difference is significant or not, a chi-square test is $\chi^2 = 12.17$ with ($p=0.16>0.05$, $df=4$). The chi-square test indicates that there is no significant difference among the two medians supporting the null hypothesis. This test shows that trainees yet not developed enough skills to choose between the wide ranges of technologies that enhance students' learning. This also indicates that a lot should be done to train student-teachers to get the full access to technology in their stay at the college.

For the question that requests trainees whether different teaching approaches require different technologies or not, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. As

one can see, there is a difference between the degrees of decision to the same item before and after a treatment. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 15.39$ with ($p=0.04<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. From this result it is clear that trainees came to understand that different teaching approaches require different technologies.

Similarly, for the question asking trainees whether they know how to use technology in problem/project-based learning or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. There is a difference between the pre-and-post decisions to the same item. To test the significance of this difference a chi-square test for independence was computed and found $\chi^2 = 8.85$ with ($p=0.065 < 0.05$, $df=4$). The test confirms that there is statistically significant difference among the two medians supporting the alternative hypothesis. Hence, from this result it is possible to conclude that trainees have got at least the basic skills of using technology.

Likewise, for the question which asks trainees whether their teaching approaches change when they use technologies in a classroom or not, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 13.2$ with ($p=0.001<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. The result of this test indicates that using technology changes the way they learn mathematics.

In the same way, for the question that asks trainees that knowing how to use a certain technology implies that they could use it for teaching, the median of a pre-response is 2.5 whereas that of the post-response is 4.0. There is a difference between the pre-and-post medians to the same item. To see whether the difference is significant or not, a chi-square test for independence shows $\chi^2 = 15.22$ with ($p=0.04<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Here, the result shows that knowing how to use a technology help them use it in the classroom.

Finally, for the question that asks trainees that different technologies require different teaching approaches, the median of a pre-response is 2.0(strongly disagree) whereas that of the post-

response is 4.0. It is clear from this that, the degree of decision made before and after the treatment both falls on the negative side of TK. To check whether this difference is significant or not, a chi-square test is $\chi^2 = 20.38$ with ($p=0.00<0.05$, $df=4$). The chi-square test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. This shows that trainees come to know that different technologies require different teaching approaches after the treatment. According to Sianjina, (2000), technology can be used not only as an information management tool, but also as a means of reaching students of diverse backgrounds indicating that teachers need to use a variety of teaching activities in their classrooms, and that variety should include technology whenever appropriate. Also Chwarz(2000), pointed out that using of technology can help teachers relate to today's students who are very media aware, prompt new approaches to curriculum, and encourage developments in teaching skills.

7. Trainees' Responses to Technology Pedagogy Content Knowledge (TPCK) Items

There were four items under Technology Pedagogy Content Knowledge (TPCK) of the questionnaire.

Item	**Technology Pedagogy and Content Knowledge (TPCK)**	χ^2	df	p-value
30	I can teach lessons that appropriately combine mathematics, technologies and teaching approaches	12.29	4	0.015
31	Integrating technology in teaching content (i.e. mathematics, science) will be easy and straightforward for me	22.27	4	0.00
32	I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn	10.37	4	0.035
33	My mathematics teacher appropriately model combining content, technologies, and teaching approaches in his teaching	17.94	4	0.001

$\chi^2_{cri} = 9.48$ $\alpha=0.05$ $df= 4$

Table 4.14 TPCK items and their chi-square test of independence

Table 4.14 shows, the four items under TPCK and their corresponding value of chi-square, the degree of freedom and the value of significance level (P) for the difference of medians between the pre-and-post-responses. The following table shows the descriptive statistics of trainees' responses on the technology pedagogy content knowledge.

Report

PCKquestionnaire		pckq30	pckq31	pckq32	pckq33
pre-responce-pck	Median	2.0000	2.0000	2.0000	3.0000
	Mean	2.1429	1.9643	2.7500	2.8571
	Std. Deviation	1.23871	1.03574	1.26564	1.11270
	Std. Error of Mean	.23409	.19574	.23918	.21028
post-response-pck	Median	4.0000	4.0000	4.0000	4.0000
	Mean	3.2500	3.7143	3.7143	3.9643
	Std. Deviation	1.57821	1.35693	1.43649	1.07090
	Std. Error of Mean	.29825	.25644	.27147	.20238
Total	Median	2.0000	2.0000	4.0000	4.0000
	Mean	2.6964	2.8393	3.2321	3.4107
	Std. Deviation	1.51261	1.48663	1.42690	1.21770
	Std. Error of Mean	.20213	.19866	.19068	.16272

Table 4.15 Descriptive statistics of trainees' responses on TPCK component

As one can see from table 4.15, for the question that asks trainees whether they could teach lessons that appropriately combine mathematics, technologies and teaching approaches or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. There is a difference between the pre-and-post decisions to the same item. To test whether this difference is significant or not, a chi-square test for independence was used and is $\chi^2 = 12.29$ with ($p=0.015<0.05$, $df=4$). The test confirms that there is a statistically significant difference among the two medians supporting the alternative hypothesis. This result indicates that trainees have got the necessary skills and ability to teach lessons that appropriately combine mathematics, technologies and teaching approaches.

Similarly, for the item that asks trainees whether integrating technology in teaching content will be easy and straightforward for them or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. As one can see, there is a difference of degrees of decision between the pre-and-post responses to the same item. To check whether this difference is significant or not, a chi-square test for independence was employed and found to be $\chi^2 = 22.27$ with ($p=0.00<0.05$, $df=4$).

This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. From his result it clear that trainees think that integrating technology with content as an easy job, however, the researcher has different views from the trainees. According to the researcher's view combining technology and content needs an expertise and requires both pedagogical and psychological considerations.

Likewise for the question asking trainees whether they could select technologies to use in their classroom that enhance what they teach, how they teach and what students learn or not, the median of a pre-response is 2.0 whereas that of the post-response is 4.0. There is a difference between the pre-and-post medians to the same item. To see whether the difference is significant or not, a chi-square test for independence shows $\chi^2 = 10.37$ with ($p=0.035<0.05$, $df=4$). This test indicates that there is a statistically significant difference among the two medians supporting the alternative hypothesis. Here, the result shows that trainees are in a position to identify and select technologies for their own teaching as the result of a treatment.

Finally, for the question asking the trainees whether their mathematics teacher appropriately model combining content, technologies, and teaching approaches in his teaching or not, the median of a pre-response is 3.0 whereas that of the post-response is 4.0. It is clear from this that, the degree of decision made before and after the treatment both falls on the negative side of TK. To check whether this difference is significant or not, a chi-square test is $\chi^2 = 17.94$ with ($p=0.001<0.05$, $df=4$). The chi-square test indicates that there is a statistically significant difference among the two medians. This result depicts that trainees agree that their mathematics teacher (most probably the researcher during the treatment) appropriately modeled and showed combining technology and mathematics.

According to Ofsted(2002) "Good teaching using ICT begins with clarity of purpose in its use. Most often this comes with experience and through thoughtful planning and collaboration between teachers integrating ICT into a scheme of work. Once pupils are working in their own or in groups, effective teaching involves teacher intervention to make sure that the objectives of the lesson are met and that pupils do not become distracted by the technology." In conclusion, the analysis of data through questionnaire, trainees' responses reviled that there is a significant difference ($P<0.05$) on the trainees' pre-and-post response to the same questions before and after the treatment of a technology. The chi-test of independence confirmed this significance. Therefore, it could be said that integrating technology to mathematics contents has an association to the

development of trainees' technology pedagogy content knowledge (TPCK).

After intervention, trainees were asked to rate technologies used in the lesson during the experiment. Some of the classroom technologies being used were Geometric sketch pad (GSP 5.0), TI-83graphing calculator, Fathom 2.1 together with an LCD Projector, computer and white-board. They were asked to rate the above technologies based on the use and relevance to teaching Mathematics. The rating scales were poor (1), fair(2), good(3), very good(4) and excellent(5). The following summary of feedback from trainees was obtained.

Item No.	**Classroom technology**	median	mean	Standard deviation	Standard Error
35	Geometric sketch pad(GSP 5.0)	5.0000	4.4643	0.69293	0.13095
36	Graphing calculator TI-83	4.0000	4.2857	0.65868	0.12448
37	LCD Projector, computer and white-board combination	4.0000	4.3214	0.54796	0.10356

Table 4.16 Descriptive statistics on trainees' responses for rating classroom technology

As table 4.16 shows that the median rating for GSP software is 5.0 implying that the use of the software during the treatment period was excellent and is a relevant technology/software to the teaching of mathematics. Similarly, the median for TI-83 graphing calculator and for the combination of an LCD, computer and white board is 4(very good). This shows that most trainees in the experiment have recognized the importance of technology to classroom instruction and seems motivated towards technology and the mode of the lesson delivered.

4.3 Presentation and Analysis of Pretest-Posttest Data

After identifying the level of trainees' Mathematics achievement based on their previous mathematics results, a pre-test was prepared and administered to both groups. The test was

prepared on the course basic Mathematics I (Math 101) which was given in Semester one. After six weeks of technology integrated lesson delivery for experimental group(MNSR G2) and a traditional lecture method for the comparison group(MNSR G1), a post test was prepared and administered to both groups to examine whether the treatment had an effect on students' Mathematics achievement or not. Based on the two test scores data analysis was done in the following section.

4.3.1 General Characteristics of Trainees Involved on the Pre-Post-Test

Before going to put the results of analysis of a pretest-posttest data, it is important to know the general characteristics of trainees who took the pretest and a posttest. The following table shows the trainees' demographic data.

Group	Test-type	Sex	Count	Percent (%)
MNSR G1 (Comparison group)	pretest	Male	31	83.78
		Female	6	16.22
		total	37	100.00
	posttest	Male	31	86.11
		Female	5	13.89
		total	36	100.00
MNSR G2(Experimental group)	pretest	Male	32	82.05
		Female	7	17.95
		total	39	100.00
	posttest	Male	32	84.21
		Female	6	15.79
		total	38	100.00

Table 4.17 General characteristics of trainees involved on the pre-post-test

As table 4.17 Shows 6 (16.22%) female and 31(83.78%) male, totaling 37 (100%) trainees of the comparison group (MNSR G1) took the pretest. Similarly, 7 (17.95%) female and 32 (82.05%) male, totaling 39(100%) trainees pretested in experimental group. Concerning posttest, 5 (13.89%) female and 31 (86.11%) male, totaling 36(100%) took the post test in comparison group. Similarly, 6 (15.79%) female and 32 (84.21%) male, totaling 38(100%) post-tested in experimental group. As the table depicts, one trainee from each group (total=2) did not took a posttest due to unknown reason. The trainees' achievement level was identified based on their previous Mathematics result as follows.

Group	Sex	High	Medium	Low	Total
MNSR G1 (Comparison group)	Male	15	11	5	31
	Female	3	2	0	5
	Total	18	13	5	36
MNSR G2(Experimental group)	Male	1	16	15	32
	Female	1	3	2	6
	Total	2	19	17	38

Table 4.18 Trainees' achievement level based on the previous Mathematics result

As table 4.18 shows, 3 female trainees achieved high, 2 achieved medium and no female trainees achieved low in comparison group. On the other hand, 15 males achieved high, 11 achieved medium and 5 achieved low in this group. Similarly, a single female trainee achieved high, 3 medium and 2 low in experimental group. Likewise, 1 male achieved high, 16 achieved medium and 15 achieved low in this group.

Based on the above descriptive data, the trainees' pretest-posttest result was compared with respect to sex and their previous Mathematics achievement. In comparison the pretest -posttest results, the between groups and within groups effect was examined using different statistical tools. In this section, the second hypothesis of the study put below was tested.

Hypothesis 2: There is no mean difference between the pre-test and post-test scores of trainees who learned mathematics with technology and without a technology with respected to gender and their previous achievement level.

Because this hypothesis is too general, a specific sub-hypothesis was reformulated as follows.

- H_0: There is no mean difference between the pre-test and post-test scores of experimental and comparison group
- H_1: There is a mean difference between the pre-test and post-test scores of experimental and comparison group.

The first task in analysis of data through pretest-posttest was to assure whether the experimental and comparison groups are matching or not. To do this, the following hypothesis was tested using an independent-sample t-test.

Hypothesis:

- H_0: There is no mean difference between the pretest mean scores of the experimental and comparison groups
- H_1: There is a mean difference between the pretest mean scores of the experimental and comparison groups.

To test the above hypothesis it is important to notice the following descriptive statistics of the groups.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pretest	1	36	24.8375	5.83658	.97276
	2	38	24.8282	6.54900	1.06239

Table 4.19 Descriptive statistics of the pretest for both experimental and comparison group

As table 4.19 above shows that the pretest mean of G1 (comparison) group is 24.837(stdDev=5.83, stdError=0.97) and the mean of G2(experimental) group is 24.828(stdDev=6.78, stdError=1.10). As one can see from the table there is a mean difference between the two groups. To test whether this difference is significant or not, an independent sample t-test was employed and the following result was obtained.

Independent Samples Test

	t-test for Equality of Means						
						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pretes: Equal varianc assumed	.006	72	.995	.00934	1.44500	2.87121	2.88989

Table 4.20 t-test for equality of a pretest mean score

As can be seen from table 4.20 above, the value of student's t is 0.006(p=0.995>0.05, stdError=1.52). This test shows that there is no significant mean difference between the experimental and comparison groups supporting the null hypothesis. Hence, the two groups are matching / equivalent. The next step was to check whether an intervention had an effect on the performance of trainees of both groups or not. It is also equally important to see whether there is a significant mean difference between the pre-and post-tests of between groups. To check this paired sample t-test was employed. To do this, first the mean difference of the two test scores, i.e, (posttest - pretest) of the comparison group was calculated and test for significance was checked. The same procedure was followed for experimental groups.

H_0: There is no mean difference between the pretest and posttest scores of MNSR G1.

H_1: There is a mean difference between the pretest and posttest scores of MNSR G1.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Posttest	23.0139	36	5.74019	.95670
	Pretest	24.8375	36	5.83658	.97276

Table 4.21 Paired samples statistics for comparison group (MNSR G1)

As one can see from table 4.21 above the pretest mean of G1 (comparison group) is 24.837(stdDev=5.83, stdError=0.97) and the mean of the posttest is 23.01(stdDev=5.74, stdError=0.95). From the table it is clear that there is a mean difference between the two test scores. To test whether this difference is significant or not, a paired sample t-test was used and the following result was obtained.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Posttest - Pret	1.82361	7.20226	1.20038	-4.26050	.61328	-1.519	35	.138

Table 4.22 Paired sample t-test for the difference of the two means (MNSR G1)

As it can be seen from table 4.22 above, student's t-value of the difference of mean for the two tests is t= -1.519, p = 0.138>0.05 with (df=35, stdDev=7.20, stdError=1.2). Since p = 0.138>0.05, the paired t-test shows that there is no significant mean difference between the two test scores of MNSR G1 supporting the null hypothesis. This could be true because, this group is a comparison group and had no treatment effects. It is very important to check whether the data is normally distributed or not in computing a t-test. The following figure depicts student's t-distribution for comparison group based on the results of the above data.

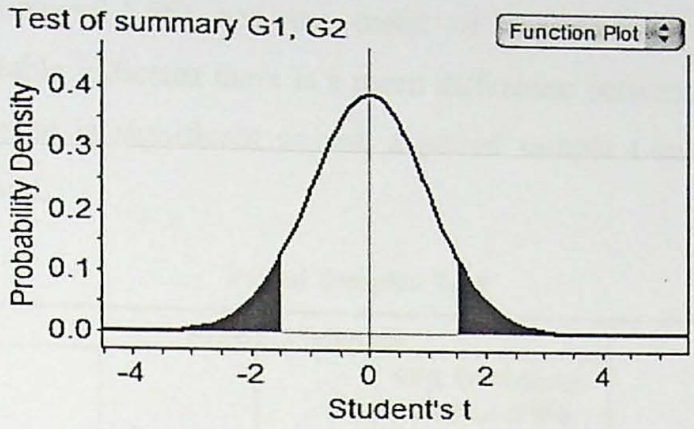


Fig 4.1 t-distribution of difference of mean for MNSR G1

As fig 4.1 shows the difference of mean of the comparison group is normally distributed. The next task was to test whether there is a significant mean difference between the pre-and-post test scores of the experimental group or not. To check this a paired t-test was employed to test the following hypothesis.

- H_0: There is no mean difference between the pretest and posttest scores of MNSR G2.
- H_1: There is a mean difference between the pretest and posttest scores of MNSR G2.

Before computing t-statistic, it is important to know the descriptive statistics of the result of the two test scores. The following summary table shows MNSR G2 (experimental) groups' test scores.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Posttest	28.5658	38	7.68921	1.24735
	Pretest	24.8282	38	6.54900	1.06239

Table 4.23 Paired sample statistics for experimental group (MNSR G2)

As one can see from table 4.23 above the pretest mean of G2 (comparison group) is 24.82(stdDev=5.54, tdError=0.1.06) and the mean of the posttest is 28.56 (stdDev=7.68, stdError=1.24). As the table indicates there is a mean difference between the two tests scores. To test whether the difference is significant or not, a paired sample t-test was employed and the following result was found.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Posttest - Pret	3.73763	8.03215	1.30299	1.09753	6.37773	2.869	37	.007

Table 4.24 Paired sample t-test for the difference of the two mean scores of MNSR G2

As one can see from table 4.24 above, t= 2.86, p = 0.007<0.05 with (df=37, stdDev=8.03, stdError=1.302). Since p = 0.007<0.05, the paired t-test shows that there is a significant mean difference between the pretest and post test scores of MNSR G2 supporting the alternative hypothesis. This significance difference of mean for the experimental group could be due to the effects of instructional technology incorporated to this group. Here once again it is necessary to check whether the data distribution of the experimental group is normal or not, to make use of the assumptions of a t-statistic. The following figure shows student's t-distribution for experimental group.

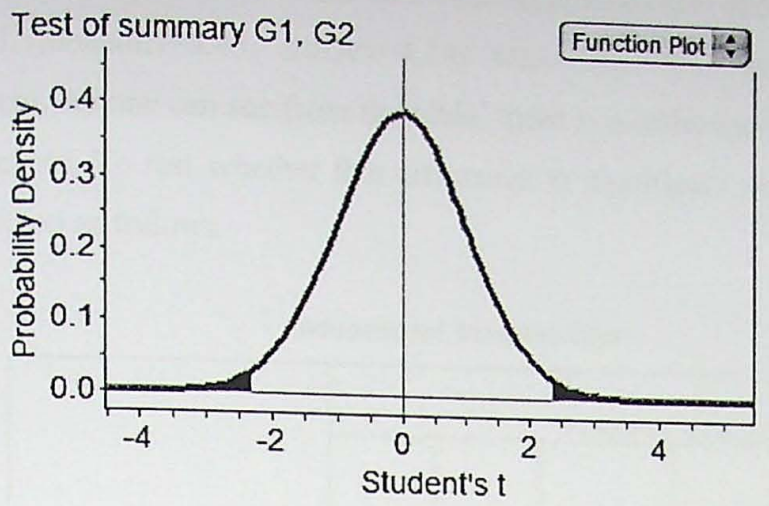


Fig 4.2 t-distribution of difference of mean for MNSR G2

As fig 4.2 shows the data of MNSR G2 trainees on the difference of the pretest and posttest means is normally distributed and fits to the assumptions of a t-test. The next procedure was to check whether there is a significant mean difference among trainees of the experimental and comparison groups with respect to sex and their previous mathematics achievement or not.

Based on the previous mathematics Achievement, trainees were divided in to three groups as high, medium and low achievers. The following comparison was made between the two groups' high achievers to check whether there is a significant mean difference between their pre-and-posttest scores or not. To do this, the following hypothesis was tested using independent sample t-test.

- H_0: There is no mean difference on the gain scores between the high achievers.
- H_1: There is a mean difference on the gain scores between the high achievers.

To test the above hypothesis it is important to consider the following summary table of higher achievers.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
MeanDifference	MNSRG1	18	-4.3983	5.68023	1.33884
	MNSR G2	2	4.4300	4.14365	2.93000

Table 4.25 Group statistics for high achievers

Table 4.25 shows that 18, trainees of MNSR G1(Meandiff=-4.39, stdDev=5.68) and 2 trainees of MNSR G2(meandiff=4.43, stdDev=4.14) were high achievers with respect to the previous achievement. As one can see from the table, there is a difference of mean between the two groups' high achievers. To test whether this difference is significant or not an independent sample t-test was computed as follows.

Independent Samples Test

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	ig. (2-tailed	Mean Difference	Std. Error Difference	Lower	Upper
MeanDiffere	Equal varian assumed	-2.113	18	.049	8.82833	4.17841	-.60685	-.04982

Table 4.26 Independent sample t-test for high achievers

As table 4.26 above shows, t= -2.11, P (2-tailed) = 0.049<0.05 with (df=18). Since p<0.05, the t-test statistic shows that there is a significant mean difference on the gain scores between the two groups' high achievers supporting the alternative hypothesis. Hence, this significant difference could be due to the effects of instructional technology incorporated to the experimental group. The effect size, Cohen's d was found to be 1.58 which is a very large effect size.

Now, the next task was to see the difference of mean (if any) among medium achievers between the two groups. To do this, the following hypothesis was tasted using independent sample t-test.

- H_0: There is no mean difference on the pretest and posttest scores between medium achievers.
- H_1: there is a mean difference on the two tests scores between medium achievers.

The following table shows a descriptive statistics of medium achievers of both the experimental and control group.

Group Statistics

	GRoup	N	Mean	Std. Deviation	Std. Error Mean
MeanDifference	MNSR G1	13	.3585	5.59335	1.55132
	MNSR G2	19	3.3026	7.86732	1.80489

Table 4.27 Group statistics for medium achievers

Table 4.27 shows that 13, trainees of MNSR G1(Meandiff= 0.358, stdDev=5.59) and 19 trainees of MNSR G2(meandiff=3.30, stdDev=7.86) were medium achievers with respect to their previous achievement. As can be seen from the table there is a mean difference between the two medium achievement groups. To test whether the difference is significant or not an independent sample t-test was used as follows

Independent Samples Test

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	ig. (2-tailed	Mean Difference	Std. Error Difference	Lower	Upper
MeanDiffere	Equal varian assumed	-2.100	30	.044	-7.88344	3.75369	-15.54951	-.21737

Table 4.28 Independent sample t-test for medium achievers

As one can see from table 4.28 above, t= -2.10, p(2-tailed)= 0.044<0.05 with (df=30). Since p<0.05, the t-test shows that there is a significant mean difference between the pretest and post test scores of medium achievers supporting the alternative hypothesis. Hence this significant mean difference could be due to the effects of instructional technology incorporated to MNSR G2 (the experimental group).The effect size Cohen's d was found to be 0.76 which is a medium effect according to Cohen (1988).

Now it remains to check whether there is a significant mean difference between the low achievers among the experimental and control group or not. To do this the following hypothesis was tested using an independent t-test.

- H_0: There is no mean difference on the pretest and posttest scores between low achievers.
- H_1: there is a mean difference of the two tests scores between low achievers.

The following table shows a descriptive statistics of the low achievers of both groups on the gain scores.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
MeanDifference	MNSR G1	5	1.7720	12.70570	5.68216
	MNSR G2	17	4.1424	8.83339	2.14241

Table 4.29 group statistics for low achievers.

Table 4.29 shows that 5, trainees of MNSR G1(Meandiff= 1.77, stdDev=12.70) and 17 trainees of MNSR G2(meandiff=4.14, stdDev=8.83) were low achievers with respect to the previous achievement level. As the above table shows there is a difference of mean between the two low achievement groups. To check whether this difference is significant or not, an independent sample t-test was used and the following result was obtained.

Independent Samples Test

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	ig. (2-tailed	Mean Difference	Std. Error Difference	Lower	Upper
MeanDiffere	Equal varian assumed	-.479	20	.637	2.37035	4.95108	2.69812	7.95741

Table 4.30 Independent sample t-test for low achievers

As it can be seen from table 4.30 above that, t= -0.479, p(2-tailed)= 0.637>0.05 with (df=20). Since p>0.05, t-test shows that there is no significant mean difference between the pretest and post test scores of law achievers supporting the null hypothesis. The reason why low achievers did not show a significant mean difference needs further investigation.

Concluding the above findings with respect to trainees' previous achievement a significance mean difference was observed between the high and medium achievers. However, this was not true in

the case of low achievers. Different research findings revealed that integrating technology with mathematics improved achievement. For instance, (Wenglinsky, 1998) revealed that when appropriately used, computers may serve to improve student mathematics achievement as well as enhance the overall learning environment of the school. Other researchers like Sinclair (2004) found that using the Geometer's Sketchpad activities helps students notice geometric details, explore relationships and develop reasoning skills related to geometric proof. Therefore, the reason why low achievers did not show a significant mean difference needs a further investigation.

On the above procedures a test for difference of mean based on the achievement level was computed. Now it remains to compare the two groups based on the gender (male and female) to see whether there is a significant mean difference between them or not. To do this, the following hypothesis was tested using independent sample t-test

- H_0: There is no mean difference between pretest and posttest scores of female trainees of the two groups.
- H_1: There is a mean difference between pretest and posttest scores of female trainees of the two groups.

The following table shows a descriptive statistics of female trainees both on the experimental and comparison group.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
MeanDifference	MNSRG1(F)	5	-4.2840	7.48239	3.34623
	MNSRG2(F)	6	9.1667	12.00319	4.90028

Table 4.31 Group statistics for female trainees.

Table 4.13 shows that there are 5 female trainees in MNSR G1(Meandiff= -4.28, StdDev=7.48) and 6 trainees in MNSR G2(meandiff=9.16, stdDev=12.0). As the table clearly shows there is a mean difference between the females of the two groups. It remains to test whether this difference is significant or not. To check this, an independent t-test was employed and the following result was obtained.

Independent Samples Test

		t-test for Equality of Means						
		t	df	ig. (2-tailed	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
MeanDiffere	Equal varian assumed	-2.169	9	.058	3.45067	6.20263	.48198	.58065

Table 4.32 Independent sample t-test for female trainees

As one can see from table 4.32 that t= -2.169, p(2-tailed)=0.058>0.05 with mean of females (df=9). This test shows that there is no significant mean difference between the two test score among female trainees of the two groups. The reason why female trainees did not show a significant mean difference needs further investigation. Now it remains to compare the achievement of males between the experimental and comparison group. With this regard to this, the following hypothesis was tested

- H_0: There is no mean difference between the pretest and posttest scores among male trainees of the two groups.
- H_1: There is a mean difference between the pretest and posttest scores among male trainees of the two groups.

To testing the above hypothesis, a summary of the descriptive statistics of male trainees in both experimental and comparison groups was put as follows.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
MeanDifference	MNSR G1(M)	31	-1.4268	7.20288	1.29367
	MNSRG2(M)	32	2.7197	6.85492	1.21179

Table 4.33 Group statistics for male trainees

Table 4.33 shows that there are 31 trainees of MNSR G1(Meandiff= -1.426, stdDev=7.20) and 32 trainees of MNSR G2(meandiff=2.71, stdDev=6.85). As the table clearly shows there is a mean difference between males of the two groups. It remains to test whether this difference is significant

or not. To check for significance, an independent t-test was used and the following result was obtained.

Independent Samples Test

		t-test for Equality of Means						
		t	df	ig. (2-tailed	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
MeanDiffere	Equal varian assumed	-2.341	61	.023	-4.14646	1.77116	-7.68812	-.60480

Table 4.34 Test for compare mean difference of male trainees of the two groups

As we observe from table4.34, t= -2.341, p(2-tailed)=0.023<0.05 with(df=61). This test shows that there is a significant mean difference between male trainees of the two groups supporting an alternative hypothesis. The effect size, Cohen's d was found to be 0.59 which is a medium effect size (Cohen 1988). This significant difference between the experimental and the comparison groups could be due to the effect of the intervention. Concluding the comparison of mean differences based on the gender, a significant difference was found between male trainees while the case was not true for females. It is important to ask why females' performance was not significant need to be examined further and other researchers are encouraged to undertake research related with gender and technology.

Lastly, a comparison of mean on the gain score between the experimental and comparison groups irrespective of gender and their previous achievement was made to examine the overall effect of the intervention. In this case, the following hypothesis was tested.

- H_0: There is no mean difference between the pretest and posttest scores of the experimental and control groups.
- H_1: There is a mean difference between the pretest and posttest scores of the experimental and control groups.

To test the above hypothesis, an independent sample-t-test was used and the following result was obtained.

Independent Samples Test

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Posttes	Equal variances assumed	-3.504	72	.001	-5.55190	1.58429	8.71012	2.39368
Pretest	Equal variances assumed	.006	72	.995	.00934	1.44500	2.87121	2.88989

Table 4.35: Independent sample t-test for the mean difference of between groups

As one can see from table 4.35, the value of t = -3.504, p(2-tailed)=0.001<0.05 with (df=72). This test shows that there is a significant mean different on the pretest and posttest scores of the experimental and comparison group supporting the alternative hypothesis. The effect size, Cohen's d is 0.82 which is a large effect size according to Cohen(1988).This significant mean difference could be due to the effect of instructional technology incorporated to the experimental group (MNSR G2) during the intervention period.

In all the above analysis only two groups were compared and level of significance was determined. But it is important to see the between groups effect on the three achievement groups to examine whether there is a significant mean difference among these groups or not. With this regard, a one-way analysis of variance (one-way ANOVA) was employed to test the following hypothesis.

H0: There is no significant mean difference among the three independent achievement groups.

H1: There is a significant mean difference among the three independent achievement groups.

The following is a descriptive statistics for the high, medium and low achievement groups in both the experimental and control group.

Descriptives

MeanDifference

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Low	22	3.6036	9.55163	2.03641	-.6313	7.8386	-12.57	22.00
Medium	32	2.1066	7.08574	1.25259	-.4481	4.6612	-6.96	29.93
High	20	-3.5155	6.09558	1.36301	-6.3683	-.6627	-13.17	7.36
Total	74	1.0322	8.08715	.94011	-.8415	2.9058	-13.17	29.93

Table 4.36 Descriptive statistics for trainees' achievement levels

As table 4.36 shows, 20 trainees have achieved high (Meandiff= -3.603,stdDev=6.09, stdErr=1.36), 32 trainees have achieved medium(meandiff=2.106, stdDev=7.085, stdError=1.352) and 22 trainees have achieved low(meandiff=3.603, stdDev=9.55, stdErr=2.036). As the table shows, there is a mean difference between the three groups. To check whether this difference is significant or not a one-way ANOVA was employed and the following result was obtained.

ANOVA

MeanDifference

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	596.038	2	298.019	5.064	.009
Within Groups	4178.312	71	58.849		
Total	4774.350	73			

Table 4.37 ANOVA table for the three achievement levels

The ANOVA summary table 4.37 reveals that the between-group mean square is 298.019 (596.038/2), and the within-group mean square is 58.849 (4178.312 / 71). The F-ratio is 5.064 (298.019 /58.849), and the p-value=0.009 < 0.05 supporting the alternative hypothesis. The test indicates that there is a significant mean difference among the three achievement groups. The effect size, Cohen's d was calculated and found to be 0.35 which is a medium effect size according to Cohen (1988). Based on the test and the effect size it would be reasonable to say that technology have had a moderate effect on trainees' mathematics achievement.

The posttest mean for differences among groups on the pretest must be adjusted to increase precision in determining the effect of treatments on the dependant variable (DV) because such differences are most likely to occur with intact groups. To do this, analysis of covariate (ANCOVA) was used. ANCOVA was also used to remove the effect of some extraneous variables than the effect of technology (IV). The dependent variable in this study was the posttest and the covariate was a pretest and the result of ANCOVA was as follows.

Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Corrected Mod	900.536[b]	2	450.268	10.621	.000	.230	21.241	.987
Intercept	1260.140	1	1260.140	29.723	.000	.295	29.723	1.000
Pretest	330.716	1	330.716	7.801	.007	.099	7.801	.787
Group	570.481	1	570.481	13.456	.000	.159	13.456	.951
Error	3010.113	71	42.396					
Total	53416.000	74						
Corrected Tota	3910.649	73						

a. Computed using alpha = .05

b. R Squared = .230 (Adjusted R Squared = .209)

Table 4.38.Test of between-subjects effect (ANCOVA)

Table 4.38 shows that the partial Eta Squared (η^2) is 0.23 and the effect size was found to be 0.53. This is a medium effect size. When testing for significance, the power of the test is 0.987. To see what kind of relationship between the difference of means among the experimental and control group, a regression analysis for curve fit was made and obtained the following relationship.

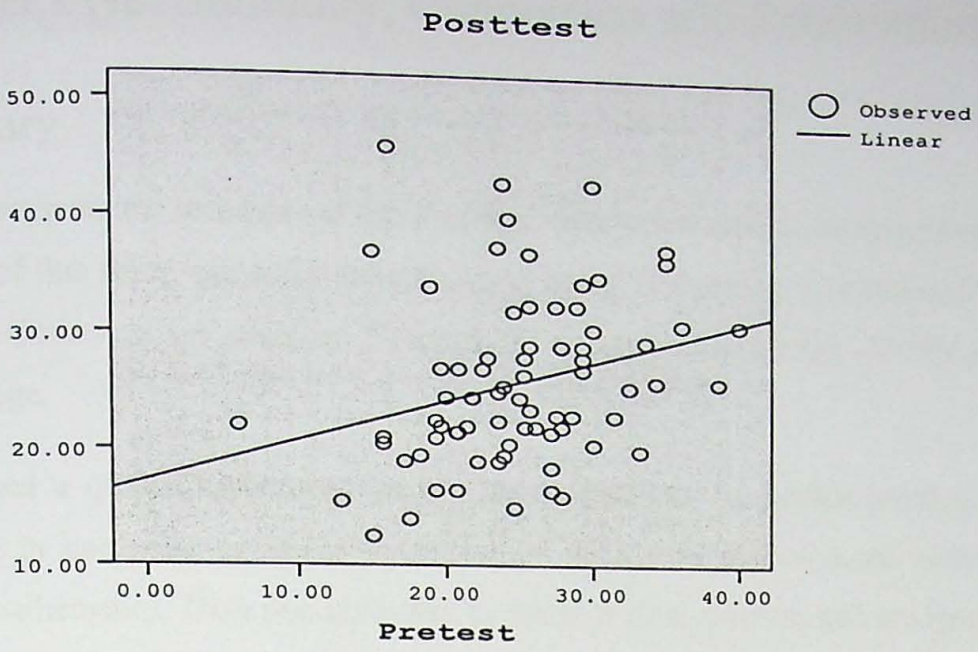


Fig 4.3 Curve fit for pre-posttest data set

As fig 4.3 shows the relationship between the pre-and-posttest of the experimental and control group is a linear relationship.

Chapter Five: Summary, Conclusion and Recommendations

5.1 Summary

This chapter presents the summary of the findings, conclusion and recommendations of the study. The purpose of this study was to investigate the effect of integrating instructional technology into mathematics classroom on trainees' Pedagogical Content Knowledge (PCK) at Arba Minch Teacher College.

The study used a quasi experimental design in general and the pretest-posttest non-equivalent group design in particular to assess the effect of integrating instructional technology into the teaching of mathematics. Data was collected by using pretest, posttest and students questionnaire. The following were the hypotheses formulated at the very beginning and latter tested.

1. There is no difference on the trainee's Pedagogy Content Knowledge (PCK) who learned mathematics with technology and without a technology (using lecture method).
2. There is no mean difference between the pre-test and post-test scores of trainees who learned mathematics with technology and without a technology with respected to gender and the previous achievement.

In order to test the above hypotheses, data was collected from 36 trainees of MNSR G1 and 38 trainees of MNSR G2 using pretest, posttest and questionnaire. All the participants were first year Mathematics and natural science regular diploma program trainees at Arba Minch College of teacher education (AMCTE). The data collected from pretest and posttests were analyzed using, student's t-test, one-way-ANOVA, ANCOVA and Chi-square test for independence. The statistical tool (a computer program) used to analyze data in this study was SPSS 15.0 and Fathom 2.1, a dynamic data handling software in some parts). On the basis of the analysis made, the major findings of the study were summarized as follows:

1. The paired sample t- test for the comparison group shows that there is no significant mean difference ($p=0.138>0.05$) between the pretest and posttest scores. But the same test for the experimental group indicates that the there is a significant mean difference ($p=0.007<0.05$)

between the pretest and posttest scores. This significant difference could be resulted due to the effect of the intervention.

2. The independent sample t-test for different achievement group between the experimental and comparison group shows that, there is a significant mean difference ($p=0.049<0.05$) among higher achievers. Similarly the mean difference among medium achievers was found to be statistically significant ($p=0.044<0.05$). But the same test for low achievers shows that there is no significant mean difference ($p=0.637>0.05$) between the two groups. The reason why low achievers did not show mean differences, needs further investigation and was left open for interested researchers.
3. The independent sample t-test for males and females between the experimental and comparison groups shows that, there is no statistically significant mean difference ($p=0.58>0.05$) among female trainees. However, the same test for male trainees indicates a significant mean difference ($p=0.023<0.05$) among the trainees of the two groups. Hence, the researcher assumes that the main reason for the observed difference among males could be due to the effect of technology integration. The reason why female trainees did not show mean differences still needs to be examined further and left open for other researchers.
4. The independent sample t- test for testing the mean difference of a pretest-posttest scores between the experimental and comparison group irrespective of gender and achievement level revealed a significant mean difference between the two groups ($p=0.001<0.05$). Therefore, the researcher assumes that this significant mean difference existed because of the effect of instructional technology incorporated to MNSR G2 (the experimental group).
5. The analysis of one-way-ANOVA for the three achievement groups to see the between groups effect also reviled a significant mean difference among the three independent groups with F-ratio 5.064 ($p=0.009<0.05$) and effect size, Cohen's $d=0.35$. This indicates that the contribution of instructional technology to the difference of mean among the three levels was medium (Cohen 1988).
6. The analysis of data obtained through trainees' questionnaire using five point Likert scale for experimental group revealed that there is an association between integrating technology in to mathematics and the trainees' Pedagogical Content Knowledge.

5.2 Conclusions

ICT is very powerful resource which we, as mathematics teachers, should need to consider when planning lesson for our students inside and outside mathematics classes. As this study evidenced that, many common ICT tools such as Geometry's sketch pad, Graphing calculator, Fathom, etc to gather with a computer have a significant role in supporting mathematics classroom instruction.

This findings of this study also indicates that students who used technology as part of the lesson showed a significant mean difference between the pretest and posttest scores than those learned mathematics using traditional lecture method supporting the principles of NTCM. The NCTM's Principles and Standards for School Mathematics and Technology states: "Technology is essential in teaching and learning mathematics, it influences the mathematics that is taught and enhances students' learning." (NCTM 2000, Technology section).

Appropriate use of technology is one aspect of teaching that trainees must demonstrate as reflective practitioners. Teachers' ability to select appropriate teaching resource (software/hardware) is an essential component of the ultimate success of effectively integrating instructional technologies into classroom teaching. According to Ertmer, Addison, Lane, Ross, and Woods (1999) "teachers, not technology, hold the key to achieving integrated technology use," while Haughland (2000) states that "how computers are used is more important than if computers are used".

The data obtained through questionnaire respondents indicates that most trainees rated the technologies being used as "excellent" and "very good" implying that they have developed a positive attitude towards instructional technology. Hence it is forwarded that teachers need to use a variety of teaching activities in their classrooms, and that variety should include technology whenever appropriate.

5.3 Recommendations

Based on the findings of this study, the following recommendations were made.

1. There are many different ways to use computers and other technology tools to facilitate the

learning of Mathematics in colleges. It is apparent to recommend at this stage that the use and practice of technology in college should start as early as possible. Because late introduction of technology tools (especially computer course) leads trainees to learn computer itself rather than learning mathematics with the help of computer.

2. This study revealed that the use of Geometer's sketch pad, graphing calculator and Fathom significantly contributed to students' Mathematics achievement and their pedagogy content knowledge (PCK). Similarly, Sinclair (2004) found that using the Geometer's Sketchpad activities helped students to notice geometric details, explore relationships and develop reasoning skills related to geometric proof which go in-line with the finding of this study. Hence I recommend to college mathematics teachers particularly (AMCTE) to make use of these softwares in combination with computers and other resource to enhance their student's Mathematics achievement and their pedagogy content knowledge.
3. College Mathematics teachers should pay a due attention to incorporate instructional technology in to their lesson and give their trainees a proper skill to work with technology tools before they leave the college. Here I want to strongly recommend for mathematics teachers in the teacher education colleges particularly in AMCTE, that technology should not be used for the sake of using a technology but rather as an integral component of the lesson.
4. Teacher Education colleges like Arba Minch, have a good deployment of computers and other instructional technologies. But what they luck is the skill of appropriately integrating the technology with a curriculum. Therefore, the college to gather with any concerned body should provide technology based trainings in a regular base for both trainees and staffs to promote effect use of instructional technology.
5. The use of ICT for instruction requires a huge investment that schools/colleges alone cannot afford. Therefore, the REB, MOE and other Governmental and nongovernmental organizations should budget/finance to help colleges and schools.
6. The participants in this study were only first year Mathematics and natural science stream trainees at AMCTE. The study would be meaningful and more comprehensive if college instructors, administrative staffs and other concerned bodies inside and outside AMCTE were involved. So, I recommend other researchers who are interested on the further investigation of the problem, to including the above subjects and fill the gap of this study.

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Appendix A

Pretest (Basic Math 101)

Part I: For the following statement, write 'True' if the statement is correct and 'False' if the statement is incorrect on the space provided. (10%)

_____ 1. Intervals are subsets of the set of real numbers.

_____ 2. A number is divisible by 6 iff it is divisible by 2 or 3.

_____ 3. Every natural number is either prime or composite.

_____ 4. 28, 75 and 121 are relatively prime numbers.

_____ 5. The product of a rational and an irrational number is always an irrational number.

_____ 6. The absolute value of every real number is positive.

_____ 7. The sum of two irrational numbers is sometimes rational and sometimes irrational.

_____ 8. Every real number has a multiplicative inverse which is either itself or different.

_____ 9. A quadratic equation has at least two real zeros.

_____ 10. Either terminating or repeating decimals are rational numbers.

Part II: For the following statement, choose the best answer from the given alternatives and write the letter of your choice on the space provided (10%)

_____ 11. What is the possible value of k such that the equation $18x+6k=0$ has solution set -1?

A. -2 B. -3 C. 2 D. 3

_____ 12. Which of the following numbers is divisible by 6?

A. 496 B. 478 C. 372 D. 548

_____ 13. $(23.43)_{five} = (\quad\quad)_{ten}$

A. 13.203 B. 13.92 C. $13.9\bar{2}$ D. $13.\overline{203}$

_____ 14. The solution set of quadratic equation $x^2 + 6x + 9 < 0$ is:

A. Φ B. R C. R^- D. R^+

_____ 15. The lowest fractional form of $0.2\bar{2}$ is:

A. $\frac{2}{9}$ B. $\frac{20}{9}$ C. $\frac{20}{90}$ D. A & C are correct.

_____ 16. The solution set of $|x+1|=2x$ is:

A. $\left\{\frac{-1}{3},1\right\}$ B. $\{1\}$ C. $\left\{\frac{-1}{3}\right\}$ D. None

_____ 17. In the digit "28145n6" which of the following numbers can be the value of 'n' so that the number becomes divisible by 4?

A. 2 B. 4 C. 3 D. None

_____ 18. Which one of the following quadratic equations <u>has no Solution</u>?

A. $3x^2 - 4x - 3 = 0$ B. $-4x^2 - 3x - 5 = 0$

C. $2x^2 - 7x + 6 = 0$ D. $9x^2 - 12x + 4 = 0$

_____ 19. When the expression $3x^2 + 3x - 36$ is factorized, the result is:

A. 3(x+3)(x-4) B. 3(x-3)(x-4)

C. $3(x-3)(x+4)$ D. $(3x+9)(x+4)$

_____ 20. The number '1' in the digit $(32142)_{five}$ represents:

A. 5 B. 25 C. 125 D. 1

Appendix B

A post test on trigonometry (Basic Math 102)

Part I: For the following statement, write 'True' if the statement is correct and 'False' if the statement is incorrect on the space provided. (10%)

_____1. An angle is formed by the rotation of a ray about its vertex from an initial position to a terminal position.

_____2. An angle is positive for a clockwise rotation and negative for anticlockwise direction.

_____3. When put in standard position, -900^0 is a third quadrant angle.

_____4. Let θ be an angle subtended by an arc of length S units in a circle of radius r. The ratio of s to r is equivalent to 1 rad.

_____5. The secant of any angle is equal to the cosecant of its complementary angles.

_____6. The reference angle for 840^0 is 30^0.

_____7. 75^0,-285^0 and 435^0 are co-terminal angles.

_____8. Co-terminal angles have the same trigonometric values.

_____9. The domain of the tangent function=$\{\theta/\ \theta \neq n\frac{\pi}{2}$, where n=1,3,5,...$\}$.

_____10. The graph of y=tanθ is decreasing for $-\frac{\pi}{2} < \theta < \frac{\pi}{2}$.

Part II: For the following statement, choose the best answer from the given alternatives and write the letter of your choice on the space provided (10%)

_____11. To which quadrant a measure of angle -1440^0 belong?

A. Quadrant I B. Quadrant II C. Quadrant III D. Quadrantal

_____ 12. $-\frac{\pi}{24}$ rad is equivalent to _____degree.

A. 7.5^0 B. -7.5^0 C. -15^0 D. 15^0

_____13. -3060^0 is equivalent to_____ in radian measure.

A. -17π B. 17π C. 18π D. -18π

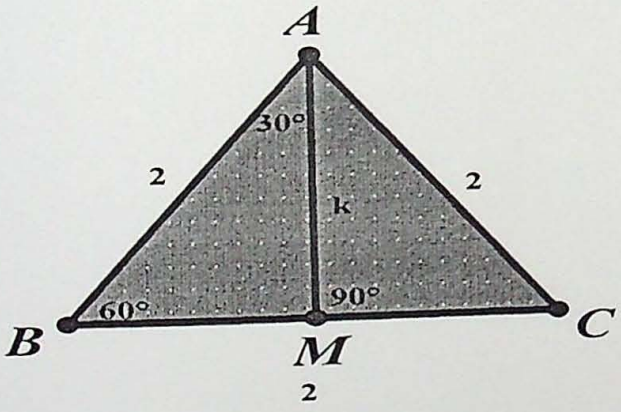
_____14. Let β be an angle in standard position and its terminal side contains a point $p(4\sqrt{5}, -2\sqrt{5})$. What is the value of tanβ?

A. $\frac{1}{2}$ B. 2 C. $-\frac{1}{2}$ D. -2

_____15. What is the value of $\cos(\frac{11\pi}{6})$?

A. $\frac{1}{2}$ B. $-\frac{\sqrt{3}}{2}$ C. $\frac{\sqrt{2}}{2}$ D. $\frac{\sqrt{3}}{2}$

_____16. ΔABC is an equilateral triangle of side length 2 units. AM is a midean with length k units. What is $\sin(60^0)$?



A. $\frac{1}{2}$

B. $\frac{\sqrt{2}}{2}$

C. $\frac{\sqrt{3}}{2}$

D. $\sqrt{3}$

_____17. Which of the following pairs of values are equal?

A. $\sin(-30^0)$ and $\sin(30^0)$ C. $\cos(-45^0)$ and $\cos(45^0)$

B. $\tan(-30^0)$ and $\tan(30^0)$ D. $\tan(-60^0)$ and $\tan(60^0)$

_____18. If $\tan\theta>0$, and $\cos\theta<0$, then θ is in quadrant_____.

A. Quadrant I B. Quadrant II C. Quadrant III D. Quadrant IV

_____19. What is cscθ, if θ is 1080^0?

A. 1 B. 0 C. $\frac{1}{2}$ D. undefined

_____20. What is the value of cot θ, if θ is 1230^0?

A. $-\sqrt{3}$ B. $\frac{\sqrt{3}}{2}$ C. $\frac{\sqrt{2}}{3}$ D. $\frac{\sqrt{3}}{3}$ E. $\sqrt{3}$

Appendix C

A Questionnaire to be filled by trainees

Dear prospective teacher! Thank you for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. Your individual name or identification number will not at any time be associated with your responses. Your responses will be kept completely confidential and will not influence your course grade.

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies that is, the digital tools we use such as computers, handheld machines, interactive whiteboards, software programs, etc. Please answer all of the questions, and if you are uncertain or neutral about your response, you may always select "undecided."

Part I: Personal information

1. Name of the school/college: _____
2. Sex: Female ☐ Male ☐
3. Age: 15-20 ☐ 21-25 ☐ 26-30 ☐ above 30 ☐
4. Department: Mathematics Linear ☐ Mathematics Cluster ☐
5. Group: One ☐ Two ☐

Part II. Technology pedagogy content knowledge

Key:1=strongly disagree, 2= Disagree, 3= undecided 4=Agree, 5= strongly agree

No.	Item	5	4	3	2	1
	TK (Technology Knowledge)					
1	I know a lot about different instructional technologies					
2	I have the technical skills needed to use classroom technology					
3	I can learn technology easily					
4	I frequently play around the technology					
5	I have had sufficient opportunities to work with different technologies					
	CK (Content Knowledge)					
6	I know about various examples of how mathematics applies in the real world					
7	I have various ways and strategies of developing my understanding of mathematics					
	PK (Pedagogical Knowledge)					
8	I can use a wide range of teaching approaches in a classroom setting (collaborative learning, direct instruction, inquiry learning, problem/project based learning etc.)					
9	I can adopt my teaching style to different learners					
10	I know how to assess student performance in a classroom					

11	I am familiar with common student understandings and misconceptions					
12	I can adopt my teaching based-upon what students currently understand or do not understand					
13	I know how to organize and maintain classroom management					
14	I have an understanding of how students learn					
15	I can structure a lesson to promote student learning					
	PCK (Pedagogical Content Knowledge)					
16	I know that different mathematical concepts require different teaching approaches					
17	I know how to select effective teaching approaches to guide student thinking and learning in mathematics					
	TCK (Technological Content Knowledge)					
18	I know about technologies that I can use for understanding and doing mathematics					
19	Using technology can fundamentally change the way people understand mathematics concepts					
	TPK (Technological Pedagogical Knowledge)					
20	I can adapt the use of the technologies that I am learning about to different teaching activities					
21	I am thinking critically about how to use technology in my classroom					

22	I have the classroom management skills to use technology appropriately in teaching					
23	My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom					
24	I can choose technologies that enhance students' learning for a lesson					
25	Different teaching approaches require different technologies					
26	I know how to use technology in problem/project-based learning					
27	My teaching approaches change when I use technologies in a classroom					
28	Knowing how to use a certain technology means that I can use it for teaching					
29	Different technologies require different teaching approaches					
	TPACK (Technology Pedagogy and Content Knowledge)					
30	I can teach lessons that appropriately combine mathematics, technologies and teaching approaches					
31	Integrating technology in teaching content (i.e. mathematics, science) will be easy and straightforward for me					
32	I can select technologies to use in my classroom that					

	enhance what I teach, how I teach and what students learn					
33	My mathematics teacher appropriately model combining content, technologies, and teaching approaches in his teaching					

Part III. Rate each of the following classroom technologies according to their relevance to the teaching of mathematics.

No.	Classroom technologies	Rating scale				
		Poor	Fair	Good	V. good	Excellent
35	Geometric sketch pad(GSP 5.0)					
36	Graphing calculator TI-83					
37	LCD Projector, computer and white-board combination					

Appendix D

Table of specification for the posttest

No.	Instructional objectives Students will be able to	content	Time spent(period)	%	No. of test items	%
1	Define trigonometric functions.	4.1 The six trigonometric functions and their properties	10	41.67	15	50
2	Sketch the graph of trigonometric function	4.2 Graphs of trigonometric functions	6	25	6	20
3	State the relations between the trigonometric functions	4.3 Trigonometric identities	5	20.83	5	16.67
4	Use trigonometric identities to solve trigonometric equations	4.4. Double angle and half angle formulas	2	8.33	2	6.67
5	Solve a plane triangle by using trigonometry	4.5 Solving triangles	1	4.17	1	3.33
6	Apply trigonometry to solve real life problems	4.6 Angle of elevation and angle of depression	1	4.17	1	3.33
		Total	24	100	30	100

N.B: The Instructional Objectives and Contents are taken from the course module Math 102 for first year MNS stream

Appendix E

Item analysis for a pretest: a) True-false (two-response multiple-choice) items

Item No.	Group	N=22	Response category		Difficulty level(P)	Discrimination power(D)	Remark
			True	False			
1	Upper	11	11		63.63	0.73	Accepted
	Lower	11	3				
2	Upper	11	10		77.27	0.27	Accepted
	Lower	11	7				
3	Upper	11		12	63.63	0.90	Accepted
	Lower	11		2			
4	Upper	11	10		72.7	0.36	Accepted
	Lower	11	6				
5	Upper	11	9		50.00	0.64	Accepted
	Lower	11	2				
6	Upper	11		11	59.1	0.82	Accepted
	Lower	11		2			
7	Upper	11		11	81.8	0.36	Accepted
	Lower	11		7			
8	Upper	11		10	63.6	0.55	Accepted
	Lower	11		4			
9	Upper	11		9	50.00	0.64	Accepted
	Lower	11		2			
10	Upper	11	9		54.5	0.55	Accepted
	Lower	11	3				

b)Four-response multiple-choice items

Item No.	Group	N= 22	Response category				Difficulty level(P)	Discriminati on power(D)	Remark
			A	B	C	D			
11	Upper	11				12	72.73	0.72	Accepted
	Lower	11				4			
12	Upper	11			10		86.36	0.09	Accepted
	Lower	11			9				
13	Upper	11		10			59.09	0.63	Accepted
	Lower	11		3					
14	Upper	11	12				77.27	0.64	Accepted
	Lower	11	5						
15	Upper	11	8				50.00	0.45	Accepted
	Lower	11	3						
16	Upper	11	12				68.18	0.81	Accepted
	Lower	11	3						
17	Upper	11			11		72.72	0.54	Accepted
	Lower	11			5				
18	Upper	11			8		50.00	0.45	Accepted
	Lower	11			3				
19	Upper	11				10	63.63	0.54	Accepted
	Lower	11				4			
20	Upper	11		10			72.72	0.36	Accepted
	Lower	11		6					

Reliability coefficient(Cronbach's alpha) was computed using SPSS and found to be 0.86.

Appendix F

Item analysis for a Posttest: a)True-false (two-response multiple-choice)

Item No.	Group	N=22	Response category		Difficulty level(P)	Discrimination power(D)	Remark
			True	False			
1	Upper	11	11		72.7	0.55	Accepted
	Lower	11	5				
2	Upper	11		11	86.4	0.27	Accepted
	Lower	11		8			
3	Upper	11		8	45.5	0.55	Accepted
	Lower	11		2			
4	Upper	11		10	72.7	0.36	Accepted
	Lower	11		6			
5	Upper	11	7		40.9	0.45	Accepted
	Lower	11	2				
6	Upper	11		9	54.5	0.55	Accepted
	Lower	11		3			
7	Upper	11	11		81.8	0.36	Accepted
	Lower	11	7				
8	Upper	11	9		50.00	0.64	Accepted
	Lower	11	2				
9	Upper	11	10		63.6	0.55	Accepted
	Lower	11	4				
10	Upper	11		11	59.1	0.82	Accepted
	Lower	11		2			

b) Four-response multiple-choice

Item No.	Group	N= 22	Response category				Difficulty level(P)	Discrimination power(D)	Remark
			A	B	C	D			
11	Upper	11				9	50	0.64	Accepted
	Lower	11				2			
12	Upper	11		9			45.5	0.73	Accepted
	Lower	11		1					
13	Upper	11	10				68.2	0.45	Accepted
	Lower	11	5						
14	Upper	11			8		50	0.45	Accepted
	Lower	11			3				
15	Upper	11				7	40.9	0.45	Accepted
	Lower	11				2			
16	Upper	11				7	31.8	0.64	Accepted
	Lower	11				0			
17	Upper	11	7				36.4	0.54	Accepted
	Lower	11	1						
18	Upper	11			9		63.6	0.36	Accepted
	Lower	11			5				
19	Upper	11				8	54.5	0.36	Accepted
	Lower	11				4			
20	Upper	11	6				36.4	0.36	Accepted
	Lower	11	2						
	Lower	11							

LESSON PLAN 2

Arbaminch College of Teacher Education

Chapter IV: Trigonometry	**Date of lesson** 26/07/2003 - 30/07/2003
Students male ____ female ____ total _____	**Level of class: 10+3 diploma students year one Time 50'**

Title of lesson: positive and negative angles

Specific Learning outcomes:- By the end of this lesson students will be able to:

- Identify positive and negative angles.
- Categorize the given measures of angles as either negative or positive angles

Teacher activity	**Time**	**Student activity**
1.Problem Posing • What makes an angle negative or positive? • Can you give me at least tree angles which are positive and three which are negative? •.	*10'*	1. • Students' will forward their prior Knowledge about negative and positive angles. • Give examples of negative and positive angles
2.Organize small-Group Investigation • Assign students in groups they can work to gather and investigate negative and positive angles by rotating the given ray.	*25'*	2. • In groups use the TI-83 graphing calculator and enter negative and positive angles and observe the output. • Also open the GSP file named lesson 1 and investigate negative and positive angles
3.Facilitate whole-Class Discussion • Motivate students to actively participate in discussion • Give feedback	*10'*	**3.** • Actively participate in discussion • Receive feedback • Will show interest to take responsibility to the success of their group.

4. Summarizing and Extending • Ask comments and questions about the lesson being taught	*5'*	4. • Will suggest the way to improve the use of GSP for angle formation. • Reflect their felling on the use of the technology
Resources and technologies: GSP file containing angles , TI-83 graphing calculator, computer for a group of students		
Assessment to be used • See each students working on the computer and helping them • Ask students to demonstrate/show how they perform • Using outshining students to help other students • Ask concept questions to check understanding		

comment

LESSON PLAN 3

Arbaminch College of Teacher Education

Chapter IV: Trigonometry	**Date of lesson** 26/07/2003 - 30/07/2003
Students male ____ female ____ total ____	**Level of class: 10+3 diploma students year one Time 50'**

Title of lesson: Quadrants and quadrantal angles

Specific Learning outcomes:- By the end of this lesson students will be able to:

- Put an angle in standard position
- Divide the whole plane in to four quadrants using GSP
- Identify 1^{st} , 2^{nd} ,3^{rd} , and 4^{th} quadrant angles and quadrantal angles

Teacher activity	Time	Student activity
1.Problem Posing • What do we mean by a quadrant? • How many quadrants do we have in a coordinate plane? • Do all angles lie in any one of the four quadrants? **2. Organize small-Group Investigation** • Ask students to form a pair group • Put angles in a standard position and indicate to which quadrant they belong • Manage time and help groups if they need **3.Facilitate whole-Class Discussion**	*10'* *25'*	1. • Students' will forward their prior Knowledge about quadrants. • Open the GSP file named "lesson 1 and investigate the four quadrants and quadrantal angles. 2. • Students can work in pairs to complete the questions. • Show commitments to complete the problem in the time provided • Complete the activities within 5 minutes 3. • Students will actively participate on the whole-Class

• Engage students in a whole class discussion • *Ask students if they found any difficulty using GSP file* • *Motivate students to ask questions and encourage those who ask questions* **4. Summarizing and Extending** • Ask comments if any to improve the use of technology • Ask if there is any difficulty using the GSP file and computers	*10'* *5'*	discussion of their investigation • Will show interest to take responsibility to the success of their group. 4. • Will suggest the way to improve the use of GSP for trigonometry. • Reflect their felling on the use of the technology
Resources and technologies: GSP file containing angles , computer for a group of students		
Assessment to be used • See each students working on the computer and helping them • Ask students to demonstrate/show how they performed the operation		

Comment

_____

_____

_____

_____

_____

LESSON PLAN 4

Arbaminch College of Teacher Education

Chapter IV: Trigonometry	**Date of lesson** 26/07/2003 - 30/07/2003
Students male ___ female ___ total ___	**Level of class: 10+3 diploma students year one Time 50'**

Title of lesson: Radian measure of angles

Specific Learning outcomes:- By the end of this lesson students will be able to:

- ❖ Draw a circle of radius r and a central angle subtended by an arc of length r to determine 1rad
- ❖ Relate the radian measure with the degree measure
- ❖ Convert radian to degree and vice versa

Teacher activity	Time	Student activity
1.Problem Posing • Ask students if they know about the units of angle measurement • *How can we determine an angle of 1 radian?* • *Can you estimate the value of* π **2. Organize small-Group Investigation** • Assign students in a group • Give activities to groups • Manage time	*10'* *25'*	1. • Students' will forward their prior Knowledge about trigonometry and their operation. • Students will suggest the technology they think helpful for trigonometry operation. • *Open the GSP file named "lesson 3" on your desktop* . 2. • Students can work in a group of 5 to complete the questions in the GSP file. • Show commitments to complete the problem in the time provided • Time to complete each activity is 5-7 minutes!

3.Facilitate whole-Class Discussion • Invite groups to display their work • Ask students to comment on others work **4. Summarizing and Extending** • Ask questions for improvement on the use of the technology	*10'* *5'*	3. • Show their performance • Give comment and receive comments 4. • Will suggest the way to improve the use of GSP for trigonometry operation. • Reflect their felling on the use of the technology
Resources and technologies: GSP File , computer for a group of students		
Assessment to be used • See each students working on the computer and helping them • Ask students to demonstrate/show how they performed the operation • Using outshining students to help other students • Ask concept questions to check understanding		

comment

LESSON PLAN 5

Arbaminch College of Teacher Education

Chapter IV: Trigonometry	**Date of lesson** 03/08/2003- 07/08/2003
Students male ____ female ____ total _____	**Level of class: 10+3 diploma students year one Time 50'**

Title of lesson: The six trigonometric functions

Specific Learning outcomes:- By the end of this lesson students will be able to:

- Define the six trigonometric functions
- Discuss the property of six functions.

Teacher activity	Time	Student activity
1.Problem Posing • How do you relate angles of a triangle with its sides? • Can you identify the six trigonometric ratios? • Can you define the six trig ratios?	*10'*	1. • Students' will forward their prior Knowledge about trigonometry and their operation. • Open the GSP file named(lesson 4)
2. Organize small-Group Investigation • Assign students in groups and monitor them • Give activities and help them to investigate using GSP. • Manage time	*25'*	2. • Students can work in a group of 5 to complete the questions in the GSP software. • Show commitments to complete the problem in the time provided • Time to complete each activity is 5-7 minutes!
3.Facilitate whole-Class Discussion • Invite groups to display their work • Ask students to comment on others work		3. • Groups present/show what they have done • Give and receive feedback

4. Summarizing and Extending • Ask if there were any problems using the GSP • Ask comment for improvement	*10'* *5'*	4. • Will suggest the way to improve the use of GSP for trigonometry operation. • Reflect their felling on the use of the technology
Resources and technologies: GSP File , computer for a group of students		
Assessment to be used • See each students working on the computer and helping them • Ask students to demonstrate/show how they performed the operation • Using outshining students to help other students • Ask concept questions to check understanding		

comment

LESSON PLAN 6

Arbaminch College of Teacher Education

Chapter IV: Trigonometry	**Date of lesson** 03/08/2003- 07/08/2003
Students male ____ female ____ total _____	**Level of class: 10+3 diploma students year one Time 50'**

Title of lesson: The unit circle

Specific Learning outcomes:- By the end of this lesson students will be able to:

- identify the properties of a unit circle
- Determine the values of six trig functions for some angles using a unit circle

Teacher activity	Time	Student activity
1.Problem Posing • Do you have any idea about a unit circle? • Why is it important to study a unit circle?	*10'*	1. • Students' will forward their prior Knowledge about unit circle. • Open the GSP file named "lesson 5'' on your desk top.
2. Organize small-Group Investigation • Organize students in groups to work together. • Monitor groups and help needy • Manage time	*25'*	2. • Students can work in a group complete the activity given. • Ask if they need help • Show commitments to complete the problem in the time provided
3.Facilitate whole-Class Discussion • Motivate groups to raise issues for discussion • *Lead group discussion*	*10'*	3. • Will raise questions • Discuss on the issues raised

4. Summarizing and Extending • Ask some questions to check understanding • Ask if difficulty raises on the use of GSP	*5'*	4. • Will suggest the way to improve the use of GSP for trigonometry operation. • Reflect their felling on the use of the technology
Resources and technologies: GSP File , computer for a group of students		
Assessment to be used • See each students working on the computer and helping them • Ask students to demonstrate/show how they performed the operation • Using outshining students to help other students • Ask concept questions to check understanding		

Comment

LESSON PLAN 7

Arbaminch College of Teacher Education

Chapter IV: Trigonometry			**Date of lesson** 03/08/2003- 07/08/2003
Students male ____ female ____ total _____	**Level of class: 10+3 diploma students**	**year one**	**Time 50'**

Title of lesson: The signs of the six trigonometric functions

Specific Learning outcomes:- By the end of this lesson students will be able to:

- Identify the signs of the six trig functions in each quadrant.
- Determine the signs of angles in different quadrants

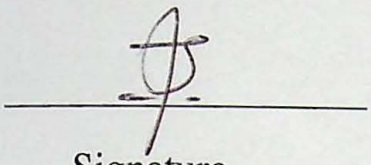
Teacher activity	Time	Student activity
1.Problem Posing • How can you decide whether a value is negative or positive for certain angle?	*10'*	1. • Students' will forward their prior Knowledge about the signs of trig functions.
2. Organize small-Group Investigation • Arrange groups and give activities to be done. • Use the four quadrants to determine the sign of a certain angle. "GSP lesson 7"	*25'*	2. • Students can work in a group of 5 to complete the questions in the GSP software. • Show commitments to complete the problem in the time provided • Time to complete each activity is 5-7 minutes!
3.Facilitate whole-Class Discussion • Promote group discussion • give feedback	*10'*	3. • Students will actively participate on the whole-Class Discussion of their investigation • Will show interest to take responsibility to the success of their group.

4. Summarizing and Extending • summarize the lesson • ask questions/comments if any	*5'*	• Will suggest the way to improve the use of GSP for trigonometry operation. • Reflect their felling on the use of the technology
Resources and technologies: GSP File , computer for a group of students		
Assessment to be used • See each students working on the computer and helping them • Ask students to demonstrate/show how they performed the operation • Using outshining students to help other students • Ask concept questions to check understanding		

comment

Statement of Declaration

I declare that the study titled "The effect of integrating instructional technology into Mathematics classroom on trainees' Pedagogy Content Knowledge at Arbaminch College of teachers' education (SNNPR)" is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of a complete reference.



Signature

28/11/2023

Date

This thesis has been done under the supervision and guidance of the following bodies.

Advisor:- Dr. Solomon Areaya

Sign:-_____

Date:-_____

Co-advisor: Ato Kassa Michael

Sign:-_____

Date:-_____