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An Exploration of Integrating Information Communication and Technology into Mathematics Teacher Education Programme

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Authors' contributions

This work was carried out in collaboration between both authors. Author SG designed the study and wrote the first draft of the manuscript. Author ZN managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

This study investigated the integration of ICT into mathematics teacher education programme at Mashonaland Orriekpen University (MOU), Mashonaland Central Region, in Zimbabwe for one year. Five trainee mathematics teachers participated in this study. The trainee mathematics teachers were purposively sampled to complete a self -administered questionnaire. The questionnaire sought their views on how ICT is being used and incorporated in the teacher preparation programme to enhance their teaching skills. Data were also obtained from documents. The documents focused on the relevance of ICT courses offered to the trainee teachers in the teaching and learning of mathematics. The major research findings were that the ICT oriented courses offered at the MOU were not mathematically aligned and less emphasis was given to application of ICT usage in the mathematics classroom. It is recommended that there is need for an ongoing training for the lecturers especially on ICT integration in mathematics.

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Keywords: ICT; mathematics; teacher education; teacher trainee.

1. INTRODUCTION

1.1 Background of Study

There is a supposition that mathematics teachers will be able to efficiently use a variety of information communication technology (ICT) related resources in the teaching and learning process to enhance the understanding of mathematical concepts. Schools in Zimbabwe encourage teachers to incorporate ICT resources in the school curricula. Zimbabwe as a government put into practice an ICT policy in 2005 that was informed by a Harvard University-guided e-readiness survey, and other policies including Vision 2020, the national science and technology policy adopted in 2002, and the Nziramasanga Education Commission Report 1999. Nziramasanga Commission suggested the integration of ICT in school curricula and in all other educational institutions, whereas, the National ICT policy implemented in 2005 recommended for the use of ICTs for pedagogical purposes in educational institutions. The incorporation of ICTs in Zimbabwe's teacher education programs is crucial, because the teacher trainees have a twofold responsibility to play: learning through ICTs and also learning how to teach through them. In Zimbabwe the Zimbabwe School Examination Council (ZIMSEC) has introduced the marking of examinations, including mathematics using ICTs. Fascinatingly, most of the schools in Zimbabwe have not fully embraced the use of ICTs in the teaching and learning process due to factors such as teachers have been less exposed or not at all trained in using ICTs. Given this scenario, it is necessary for this study to look into how ICTs are being integrated into teacher training programs, since teachers are responsible for the greater part of the curriculum implementation.

Information and communication technology (ICT) has the potential to change teaching and learning processes. ICTs are used by teachers for various purposes to enhance teaching and learning including general communication, playing games, doing homework, searching for information, and practicing and drilling such as foreign language learning or mathematics (OECD), [1]. At the same time ICTs have changed the instructional context requiring that teachers be able to effectively manage evolving teaching and learning paradigms and related processes. ICT equipment is quickly evolving technologically making it difficult for teachers to make informed and sustainable choices regarding which devices to use. In addition, this rapidly developing digital landscape results in additional challenges to prepare teachers to integrate ICT into the classroom, [2]. Because of rapid development in ICT, particularly the Internet, traditional initial teacher training as well as in-service continued training institutions worldwide are undergoing a rapid change in the structure and content of their training and delivery methods of their courses. The UNESCO Competency Framework for Teachers advocates that teachers know basic hardware and software operations, and to be flexible in order to use a variety of subject-specific tools and applications (UNESCO), [3]. If teachers are not exposed to this variety of ICT facilities and devices the confidence to make use of the devices may be compromised. Zindi & Ruparanganda [4] argue that although educators appear to acknowledge the value of ICT in schools, difficulties continue to be encountered during the processes of adopting these technologies in Zimabwe. The act of integrating ICT into teaching and learning in mathematics is a complex process and one that may encounter a number of difficulties. According to Zindi & Ruparanganda [4], teachers specifically starting to learn ICT require more time. These include the time needed to locate Internet advice, prepare lessons, explore and practice using the technology, deal with technical problems, and receive adequate training. According Zindi & Ruparanganda [4], the issue of training is certainly complex because it is important to consider several components to ensure the effectiveness of the training. These include time for training, pedagogical training, skills training, and an ICT use in initial teacher training. Teachers need to be specifically trained in order to integrate ICT in their teaching. It is therefore, the purpose of this paper to find out how ICT is being integrated into the mathematics teacher education programme.

1.2 Research Questions

1. What ICTs are used in mathematics teacher training programs at MOU?
2. How is ICT integrated into the mathematics teacher education curriculum?
3. What are the challenges faced in ICT usage and integration in mathematics teacher training programs at MOU?

2. RELATED STUDIES

Ittigson & Zewe [5] noted that technology is essential in teaching and learning mathematics. Research has revealed that ICT can change the way teachers teach and that it is especially useful in supporting more learner-centered approaches to instruction and in developing the higher order skills and promoting collaborative activities (Haddad), [6]. ICT teacher training can take several forms. Teachers can be trained to learn how to use ICT or teachers can be trained through ICT. ICT can be used as a core or a complementary means to the teacher training process (Collis & Jung), [7].

Nowadays, a range of ICT can facilitate not only delivery of instruction, but also learning process itself. Furthermore, ICT can promote international collaboration and networking in education and professional development. There is a variety of ICT alternatives, from video conferencing through multimedia delivery to web sites. Keong, Haran and Daniel, [8] pointed out that ICT application may include use of projectors (multimedia), internet activity, presentation software, search engines and also simulation programmes. Forgasz and Prince, [9] argue that knowledge of the use of software on the part of the teachers is the criterion for integrating ICT into mathematics lessons and also a sound knowledge on how to integrate it is another critical success factor. It implies that trainee teachers need to have the knowledge of the use of software and how to apply it.

2.1 ICT Use as Main Content Focus of Teacher Training

In several developing countries, ICT training for teachers is focused on developing computer literacy, which is an essential element for integrating ICT in education; however it is noted by InfoDev, [10] that effective training should not stop at computer literacy but should replica efficient teaching practices. Although training preparations on ICT are far from covering all teachers in Africa, InfoDev, [10] reported that since 2007 an estimated 61 different ICT-related teacher training and professional development programmes, projects, and courses were in progress in Africa.

In Africa teacher professional development and training programmes for ICT focus on in-service teachers, but progressively more so there is a change towards the inclusion of ICT related training within pre-service teacher training programmes (Farrell and Isaacs), [11]. Regardless of the augmented emphasis on training teachers on the use of ICT, decisions to make such training obligatory are not always assured. In the case of Rwanda, such courses in teacher training programmes have not persistently been a requirement for teaching where it was officially considered an elective subject within its national curriculum (Davis), [12].

Jung, [13] reported a case of Singapore teacher training curriculum that consist of three types of ICT courses for trainee teachers: basic ICT-skill workshops, a 30-hour ICT foundation course, and a 26-hour elective course. Additionally, there is a 6 to 12 hours of ICT integration into each curricular subject class. Basic ICT skill workshops cover word processing, PowerPoint, Internet literacy, and other technical skills. A 26-hour elective course covers the design and production of computer-based instruction. A 30-hour ICT foundation course entitled “Instructional Technology” covers: “learning, thinking and the effective use of instructional technologies in the classroom; instructional planning models; selecting, creating, evaluating, and integrating instructional technologies and resource materials; promoting creativity and complex thinking through ICT project work activities; and organizing and managing instructional activities with appropriate ICT resources in the classroom. Furthermore, trainee teachers are required to be on a five week of practicum throughout the first year of their training and ten weeks in the second year, of which they are expected to use ICT while teaching. This approach of using ICT as the main content focus of teacher training emphasizes the development of basic ICT skills, design and development skills, and pedagogical strategies. These trainee teachers reported that the 30 hours of instruction was not enough time to gain proficiency in ICT-pedagogy integration, and some wanted more ICT-pedagogy integration in the practicum (Jung), [13].

It is also important to capture for how long teachers are trained on ICTs. Research shows that ICT training should not be too short in duration nor should it be delivered sporadically (Du Toit), [14]. UNESCO-UIS, [15] noted that best results are obtained when teachers are exposed to training over an extended period of time, or if mentorship programmes or focus group discussions among teachers to exchange best practices are held regularly. Teacher

professional development is a process and not an event (Infodev), [10].

2.2 ICT Use as Part of Teaching Methods

In this method, the teachers integrate ICT into their training to aid various aspects of training. The two cases below show how a multiplicity of ICT is adopted as an element of useful training techniques.

Captured Wisdom (http://www.ncrel.org/cw/) is a resource developed by the federally-funded (USA) North Central Technology in Education Consortium for K-12 teachers. It has used multimedia technologies to help teachers to see how technology can be integrated into the classroom. Its multimedia based library comprised of stories about teachers who are making evocative and inventive uses of technology in their teaching. It also contains video to explain how teachers use technology in the classroom. The real examples of teachers integrating technology in the classroom could engender a successful practice for other teachers. In this particular case, teachers could learn how to use ICT by authentic processes of ICT-integrated training.

UNICEF's Teachers Talking About Learning (http://www.unicef.org/teachers/) as well, demonstrates the applicability of this method to ICT teacher training. It uses the Internet and television to supply teacher training resources and practical links and also promotes teacher debates. These training techniques concur with (Jung), [16] who argued that teachers are assisted significantly by actively experiencing ICT skills as a student.

2.3 ICT as Core Technology for Delivering Teacher Training

The digital technology is repeatedly becoming the hub technology of ICT teacher training. The Internet, while not always available in all regions in developing countries, is another form of ICT that can deliver ICT-enabled distance education. An Internet based Open and Distance Learning (ODL) programme for Teachers on ICTs can be found in Lesotho, where academics were trained on instructional design using ODL (Daniel & Menon), [17]. In the Arab States, The National Centre for Educational Innovation and Experimentation (CNIPE*)* offers teachers an online learning environment on how to create multimedia educational content. In Latin America teachers are trained via ICT-enabled distance portals, grouped together under the Latin American Education Portals Network (RELPE*)*. Countries in the region control educational portals that offer local educational content to learners and teachers (Gutterman, et al), [18].

Another case of adopting ICT as the core delivery means of teacher training can be found in the LearnLink project (http://www.aed.org/learnlink) supported by USAID and AED. The project has employed computer mediated professional development programs to develop training and maintain services for teachers in numerous developing countries, [7] for instance, in Morocco and Namibia, the Computer Assisted Teacher Training project has developed computer-assisted teacher training courses and communications network for trainee teacher. Similarly, the Connectivity for Educator Development project in Uganda was designed to improve professional development for teachers, focusing on multimedia-assisted teacher training and digital library resources. An Internet-based online teacher training facility was developed and was set up to provide a flexible and interactive training setting for teachers (Jung), [3].

One of the pre-requisite to develop teachers' ICT skills and promote ICT-pedagogy integration in the classroom is the provision of ICT-based training atmosphere where access to materials, peers, and networks of experts and advices can be acquired in relation to technology or pedagogy. Incidentally, the approach of using ICT to support teachers' on-going professional development and networking can be very effective as long as organized support is provided (Pacey), [19].

2.4 ICT Integration Challenges/Barriers

Becta cited in Zindi & Ruparanganda [4] reported that the issue of training is certainly complex because it is essential to consider several components to ensure the success of the training. These consist of time for training, pedagogical training, skills training, and an ICT use in initial teacher training, lack of teacher ICT skills ,lack of confidence; lack of pedagogical training; lack of follow-up of new ICT skills and lack of differentiated training programmes.

Correspondingly, Zindi & Ruparanganda [4] concluded that lack of training in digital literacy, lack of pedagogic and didactic training in how to use ICT in the classroom, lack of professional development in technology and lack of training

concerning the use of technologies in mathematics specific areas were obstacles to using new technologies in classroom practice. Lack of infrastructure such as electricity and computers also hamper the uptake of computer skills in various countries (ICT Works), [20].

3. METHODOLOGY

3.1 Research Design and Methodology

The research design used for this study is a mixed method research approach. A mixed methods research design is a procedure for collecting, analyzing, and "mixing" both quantitative and qualitative methods in a single study or a series of studies to understand a research problem. According to Creswell, [21] mixed method research is based on pragmatic world view or knowledge claim, i.e., it is consequence-oriented, problem-centered, and pluralistic.

3.2 Data Sources and Sampling Techniques

Both primary and secondary data were used. The primary data were gathered through questionnaires. The questionnaires comprised open-ended questions. Secondary data were gathered and retrieved from teaching course outlines. One way of getting credible data is the use of multiple data collection sources. In this study documents and questionnaires were used as one way of methodological triangulation. Questionnaires were constructed after consulting theory and previous research. The questionnaire comprised of open - ended questions that generated both qualitative and quantitave data. Inductive and interpretive data analyses were used in this study. The course outlines used are curriculum documents that have been approved by Zimbabwe Council for Higher Education (ZIMCHE) after several reviews. The questionnaires were pilot tested at a different university to ensure validity and reliability of instrument.

The population of the study consisted of fifteen first year Bachelors of Science in mathematics general degree trainee teachers from MOU. Five trainee teachers were purposively sampled. Permission to carry out the study at MOU was granted by the relevant authorities. Ethical issues, such as informed consent of trainee teachers involved, confidentiality anonymity of participants, and access to findings were communicated to the selected trainee teachers.

4. RESULTS AND DISCUSSION

4.1 Secondary Data from the Course Outlines

4.1.1 ICT integration in course outlines

Trainee teachers enrolled at the university program are required to take one ICT literacy course, introduction to Computer Skills besides other foundations courses and the subject specific courses. Some of these courses also involve use of ICT, for instance telematics and introduction to mathematics computing. The course, introduction to Computer Skills was designed for all first-year students enrolled at the university. Its main objectives include learning how information technology can be used as a tool in various organizations, appreciating windows operating system platform in order to work comfortably and exposing students to word processing, spread sheets and databases, graphical presentations embedded in Microsoft office. The course content reveals that students are taught computers in general; history of computers hardware and software may not be of greater use in mathematics teaching. This course utilizes in-class delivery methods. More so, from the course content, it shows that practical assessment contribute only fifteen percent (15%) to one's pass mark whilst theory examination constitute seventy percent (70%).

The objectives of this course do not cater for the specific integration of ICT into teaching and learning in classroom and school contexts in mathematics. The emphasis of this course is on computer appreciation skills training. The course is not subject based but helps students to appreciate the basic ICT skills relevant to enhance their studies in general.

Telematics is an ICT oriented course taken by the third-year mathematics trainee teachers at MOU University and it aims at using an advanced Texas Instrument (TI 83-TI92) calculators as hand-held technologies that can assist in the teaching and learning of various concepts in pure and applied mathematics such as mathematical finance and mathematical and statistical programming. The calculators can give students both mathematical manipulation and visual skills through excellent graphical displays and keystrokes pressing. For this reason, the calculators are sometimes referred to as graphical calculators.

Table 1. Course content: Introduction to mathematics computing

Hours	Content
2	A review of the different parts of the computer Communicating with the computer
2	Interpreters Command line Graphical User Interface(GUI)
4	Introduction to LINUX Basic shell commands
4	Text Editors Vi Emacs Controlling emacs from the keyboard
2	Creating directories and files Saving files Moving files and directories
2	Editing files in emacs Moving and deleting some text Copying some text
2	Introduction to the Latex Language Creating documents in Latex Document structure Report Article
4	Maths environments Typesetting mathematical text Displaying equations Creating numbered and unnumbered equations
2	The Greek alphabet
6	Displaying matrices Creating lists and tables Multicolumn tables Borderless tables Numbered and unnumbered lists Displaying graphs
2	Introduction to Mupad software package Simple arithmetic using mupad
2	Algebra in Mupad Simplifying expressions Factorization Substitution Solving equations
2	Plotting graphs in Mupad
2	Differentiation Integration Partial derivatives
2	Numerical solutions of ODES
2	Numerical solutions of ODES continued
2	Introduction to the Octave software package Simple arithmetic in octave Matrics algebra in octave Eigen values and eigen vectors Iterative methods in octave Octave M-files

The TI-83 is a graphic calculator and it is one of the ICT tools that can be used in enhancing ICT integration. However the link between the use of this tool with how to apply this in teaching and learning (practical aspect) is not evident from the course content. The instructional design of how to use the calculators as hand-held technologies guides the teaching and learning of both pure and applied mathematics skills. Furthermore teaching, learning and assessment of this course is theoretical, trainee teachers are required to write down commands in the examination.

The goal of the Introduction to Mathematics Computing course is to make trainee teachers more sophisticated in their knowledge of computing in mathematics. The course is also designed to ensure that in-service teachers develop an appreciation and understanding of the LATEX/Win Edit language, experience appropriate teaching skills when using mathematical software in the teaching and learning of mathematics and develop competencies in an ability to apply mathematical computing techniques to solving practical problems.

4.2 Results from Trainee Teachers' Questionnaire

This section discusses the results from open-ended questions from a questionnaire. The study revealed that all trainee teachers would do the introduction to computing skills, 20% telematics and 10% mathematics computing. It is evident that MOU offers a number of ICTs oriented courses. However, all the above courses are done within a semester and each course has a minimum of 48 contact hours and, this makes the courses a once off learning experience. This contradicts UNESCO-UIS, [15] who proposed that the best results are obtained when teachers are exposed to training over an extended period of time. As was noted by Jung, [13] in Singapore, trainee teachers are required to implement ICT skills that they would have acquired during training in practicum based situation, at MOU it is not mandatory for trainee teachers to deliver lessons integrating ICT skills during their teaching practice.

Since it is mandatory for all trainee teachers to do, introduction to computing skills sore it therefore implies that all graduating teachers from MOU would have the basic computer skills. In this course ICT training for teachers is focused on developing computer literacy, which is an essential element for integrating ICT in education (Infodev), [10]. For all courses except mathematics computing lecturers indicated that

trainee teachers write a theory examination. This is also different from the situation in Singapore where Jung, [13] indicated that trainee teachers design and produce computer-based instruction. The three courses offered at MOU revealed that how ICT is being integrated into the teacher training program. In this study the courses are taught as standalone courses that are not integrated to specific subjects.

Trainee teachers confirmed that they use LCD projectors sometimes on weekly basis for presentations and tutorials in other courses but not during mathematics lecturers. Teachers' skills are the major criterion for ICT integration. Therefore lecturers at MOU need to impart these skills to trainee teachers. Trainee teachers reported that they use laptops, desktops, Microsoft Office packages, internet and flashdrives almost on daily basis but not necessarily for teaching and learning but for their research work. Trainee teachers indicated that the mathematical packages are only used for their research work. The participants also

Table 2. Course content: introduction to computer skills

Hours	Content
4	History of Computing Early Computers Von Neumann Computer Fundamental Computer terminology and concepts
8	Computer Classifications Types of computers Measuring time, size and processing power Data representation
8	Computer hardware Input, output and storage devices Peripheral devices
8	Computer software System software (system software overview and operating systems) Drivers and Utilities Application software (general purpose and application specific)
8	Database design and management Foundation of database concepts Database design management approach Using database management software Data resources management and data structures.
12	Telecommunications Accessing files and databases Telecommunication models LANs, MANs and WANs Telecommunications Media Telecommunications Processors Telecommunications Network Topologies Internet E-mail
8	Computer viruses Types of viruses How viruses work Sources of viruses How to avoid viruses What are Trojan horses and computer worms
8	Practical Operating Systems Windows XP Screen Starting and shutting down a computer Starting and quitting programs Creation, manipulation and organization of files and folders Word Processing: MS word Spreadsheets: MS Excel Database Management: MS Access Graphics Presentation: MS PowerPoint

Table 3. Course content: Telematics

Hours	Content
2	Introduction to the TI 83 graphing calculator Introduction to the various modes of the calculators The keypad, Different features on the keypad and how they function
4	The catalogue Resizing the viewing screen (use of the zoom features) The math options for numbers (real and complex), decimals and angles
6	Graphing options for functions Calculation of zeros, intercepts, maximum and minimum values
6	Construction of table of values and split screen Calculation of derivatives and numerical integrals of functions
6	Parametric graphing and polar graphing Sequential graphing mode
6	The matrix algebra on the graphing calculator Finding determinants, inverses, eigenvalues and eigenvectors Solving systems of linear equations
6	Statistical graphs(histograms, box and whiskers plots), Inferential Statistics (the normal distribution, z - test, T- test, Chi-square test etc)
6	Regression analysis (linear, quad, cubic) Application links and programming (programs for calculating area, Volume of cylinders)
6	Financial applications Application links (sending and receiving information using the TI 83)

Table 4. Use of ICT resources by trainee teachers

ICT tools & uses	Always (%)	Often (%)	Sometimes (%)	Never (%)
LCD projector		20	80	
Internet	100			
Flashdrives	10	40	40	
Microsoft packages	60	40		
Laptops	100			
Desktops	100			
Presentations			10	90
Tutorials				100
Mathematics packages	50	10	30	10

indicated that the their institution has a Moodle platform, where they are supposed to download study materials uploaded by lectures, and also interacting with them, however it was shown that this worked very well when uploading course work marks and final examination marks and was not necessarily for teaching and learning purposes.

4.3 Challenges to ICT Integration

Lack of competence was one of the most common obstacles to trainee teachers' use of technology in the teaching of mathematics. The major problem linked to the competence barrier was the lack of training or effective training. 80% of the participants had no basic skills in using ICT technology as well as training in the integration of this technology into interactive and effective teaching.

Participants also revealed that about ten trainee teachers share a single calculator in telematics course. This might also contribute to resorting to theoretical examination that hampers to development and use of ICT skills in teachers. Furthermore, participants indicted that the 48 hours contact time were not adequate to impact all the necessary ICT skills for teaching and learning of mathematics.

Though at MOU there is Moodle, participants' concerns were on the internet and electricity availability. This concurs with (ICT Works), [20] who highlighted lack of infrastructure such as electricity as impediments ICT integration in many countries.

Lastly, the participants reported that the three courses required specialized lecturers who were trained in those areas, to the extent that trainee

teachers would not be able to do the courses due to lack of specialized manpower. This implies that some of the lecturers lack expertise or they were never trained in that line of ICT.

5. CONCLUSION

From the findings, it can be concluded that MOU university offers ICT oriented courses that are not subject based, application of ICT usage and integration in the classroom is not emphasized in courses provided, main emphasis is on theory rather than practice, and there is little or no assessment of teaching using ICT with trainee teachers. The researcher concluded that mathematics lecturers do not integrate ICT in their teaching and learning mainly due to inadequate training on e- planning, e-content instructional design, lack of subject specific training on ICT usage and integration, lack of knowledge on specific software for mathematics topics, limited access to ICT.

6. RECCOMENDATIONS

The researcher came up with the following recommendations;

- Lecturers require different types of professional development in the use of technology. This can be in the form of formal training in technology courses, training of lectures in the use of software packages instructional strategies and delivering of lectures integrating technology in mathematics
- Lecturers require ICT training so that they are competent when using computers in the teaching and learning of mathematics.
- Effective professional development must be offered to lecturers always since in this field of ICT there are quick changes that take place from time to time.
- All the courses offered at MOU university may adopt the Buffet model of ICT integration which advocates for a mixture of both face to face activities and online interactions and assessment where one‘s styles and skills are assessed through producing a project and presentations using ICT.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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