

EXPERIENCES AND ATTITUDES OF MATHEMATICS TEACHERS TOWARD THE USE OF TECHNOLOGY IN MATHEMATICS TEACHING AND LEARNING IN BOTSWANA SENIOR SECONDARY PUBLIC SCHOOLS: A QUALITATIVE RESEARCH

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Abstract: The purpose of this study was to establish how senior secondary teachers use technology in mathematics lessons. The study also investigated the attitudes of Botswana secondary school teachers toward the use of technology in mathematics education and the challenges that they encounter when integrating technology in mathematics instruction. The target population was mathematics teachers from public senior secondary schools in Gaborone. The sample was drawn from two public senior secondary schools in Gaborone and their mathematics teachers. Purposeful sampling was used to select the schools. The instrument was semi-structured interviews for the teachers. Validity was done by input of supervisor and pilot study. Qualitative data from the teachers' interview analysed to assist in responding to the research questions. The analysis was done by considering the similarities and convergence from the responses. The findings of the study revealed tha teachers demonstrated positive attitudes toward the use of technology in mathematics education. The findings also indicated that teachers are willing to integrate technology in mathematics education despite the challenges that they experience.

1. INTRODUCTION

There have been changes and reforms in Botswana education system concerning the curriculum, infrastructure, schools' enrolment, and teachers' education (Mafuraga & Moremi, 2017). The Revised National Policy on Education (RNPE), which guides educational policy, has improved the adoption and incorporation of science and technology in education. Conforming to this policy, computers have been provided to schools to promote information and communication technology (ICT) awareness such that both junior and senior secondary schools in Botswana have personal computer laboratories (Mpoeleng, 2016). This shows the extent to which the country is committed to ICT integration and use in its educational system. Since the late 1990s when the policy was first implemented, the curriculum that instils computer education has been made for schools. In order to upgrade and enhance teachers' knowledge and skills on computer technology, some short courses were provided. In addition, pre-service programs that instill computer courses have also been introduced in tertiary and higher education to equip teachers with technology in teaching. According to Presidential Task Force (1997) "all schools will have access to a computer, and to computer-based communications such as the internet" (p.7). The question then could

be, to what degree has this been achieved and what challenges are there in efforts to ensure accessibility of computers by students and staff? Clearly, impediments are there as Asongu, Orim and Nting (2019) pointed to a significant inequality between urban and rural areas pertaining access to ICT services. The authors mention lack of electricity in rural areas and high internet charges among other challenges, which disadvantage the rural area residents as compared to those in the urban centers. Regardless of these challenges ICT in the modern world is vital in the teaching and learning process and life in general.

2. LITERATURE REVIEW

The Botswana government also introduced a national ICT policy called Maitlamo (Maitlamo, 2007). This policy is a document designed to guiding and transforming ICT use in the country. According to the document, its key goals are “creation of an enabling environment for the growth of an ICT industry in the country; Provision of universal service and access to information and communication facilities in the country; Making Botswana a Regional ICT Hub so as to empower Batswana and to make the country’s service sector globally competitive” (Maitlamo, 2007, p. 4). This can be fairly noticed through the use of ICT in the school system. Maitlamo also has a component called ThutoNet which focuses on the promotion of e-learning which attempts to make sure that schools have computers and are connected to the internet, as well as outsourcing funds for continued ICT usage in the schools (Mogwe & Balotlegi, 2020). This is meant to increase ICT usage in education. All schools were supposed to be furnished with computers and have internet connectivity and all teachers should have learnt basic computer skills by the end of the year 2010 (Mogwe & Balotlegi, 2020). Siamisang, Kumar, Narayanan and Chandirakasan (2018) proclaimed that the country seeks to have very good ICT and lead the region in the invention and supply of information. This was verified by the formation of the Ministry of Infrastructure, Science and Technology in 2002 devoted to ICT infrastructural development. This shows that efforts are being made to make ICT available and affordable to the citizenry. All junior secondary schools in Botswana achieved fully equipped computer laboratories within no time. This was a breakthrough by the government to equip all junior secondary schools with these ICT resources even though they are not fully utilized due to several reasons.

According to Chen and Wu (2020) availability of resources in education is essential as at times the resources may be available but not accessed by the users: which makes them meaningless. Tabach and Trgalová (2019) found that teachers complain about the difficulty to access computers. “Computers had to be booked in advance and the teachers would forget to do so, or they could not book them for several periods in a row when they wanted to work on several projects with the students” (p. 50). This means that a teacher would fail to access ICT materials due to sharing limited

resources with other teachers. The inaccessibility of ICT resources is not always merely because of non-availability of hardware and software materials within the school. It may be due to some factors like poor quality, poor resource organization or lack of interest by teachers (Hosman, 2018).

Hinostroza (2018) is of the view that teachers cannot be expected to overcome the challenges preventing them from using ICT without good technical support from both the classroom and whole school resources. Lack of technical support from both primary and secondary schools prevents ICT use in education (Van Niekerk, 2018). Technical problems such as waiting for websites to open, failing to connect to the internet, printers not printing, malfunctioning computers, and teachers having to work on old computers have a negative impact in education (Viberg, Grönlund, & Andersson, 2020). "Other important limitations were lack of adequate professional development concerning technology, limited physical resources, inadequacy of resources, limited access to technology and lack of technical support, competence and confidence" (Almanthari, Maulina, & Bruce, 2020, p. 3). ICT support in schools allows teachers to use ICT in teaching without wasting time fixing software and hardware problems (Djoub, 2017). According to Hosman (2018) addition of ICT in teaching requires a technician otherwise lack of technical support can be a very serious challenge. Poor technical support appeared to be one of the two main challenges to ICT integration in science education in schools in Turkey (Birgin, Uzun, & Akar, 2020). In Saudi Arabia, mathematics and science teachers would agree using computers in their lessons, but they argued that technical service or hardware problems were the main drawback (Kareem, 2018). Technical problems interfere with the smooth lesson delivery by teachers no matter the teaching experience they have in the field (Djoub, 2017).

The problem most commonly referred to in the literature is lack of effective training (Djoub, 2017; Hosman, 2018). One research in Turkey found that inadequate in-service teacher training was the main problem with implementing new ICT in education (Serrano, 2017). Viberg et al. (2020) established that the subject of training is surely difficult since a number of components need to be considered in order to ensure training effectiveness. These include time for training, pedagogical training, skills training, and an ICT use in initial teacher training. Similarly, research by Tenai (2017), concerning numerous subjects concluded that lack of training literacy, lack of pedagogic and informative training in how to use ICT in the classroom and lack of training concerning technology use in specific subject were obstacles to using new technologies in classroom practice. Some of the Saudi Arabian studies reported similar reasons for failure in using educational technology: the weakness of teacher training in the use of computers, the use of a delivery teaching style instead of investment in modern technology (Tenai), as well as the shortage of teachers qualified to use the technology confidently (Rosenberger, 2017).

3. THEORETICAL FRAMEWORK

This study was guided by the constructivist theory of learning. The basic tenet of constructivism is that students acquire knowledge through doing as opposed to observing. Students convey prior knowledge into a learning condition which allows them to evaluate and analyse their understanding of it. This learning process is repeated until they can show their understanding of the subject. The theory was selected because it builds on prior knowledge: students make connections to new material using what they already know. When students make these connections, they are learning new material and relating it to what they already know (Mattar, 2018). The principles which inform the study are readiness and generation, where the former deals with the experiences and contexts which enable learners to be eager to learn and the latter deals with operating beyond the information given (i.e. instructions must be generated in a way that simplifies extrapolation).

Many educators nowadays think that the constructivist theory is a relatively new theory in education while the tenets of constructivism can be traced back to Socrates. Socrates was well known for asking his students questions that would stretch their minds and force them to think in a higher level (Xie & Cai, 2018). Aseeri (2020) declared that, "thinking is one important topic that contributes to refining the learner's personality and developing him in all different areas of life. It is a mental activity that includes numerous different processes or skills that are capable of growth, development and learning." (p. 64). The mind's primary purpose is to create and to see things in a way that can be organized into a schema that helps the mind to see them as being real. Piaget was a strong supporter of cognitive development. He had a belief that as children grow older, they perceive the world through different experiences, and that, children have totally dissimilar viewpoints than adults (Mustapha et al., 2020). Piaget emphasized that when knowledge is constructed inside oneself, it is inspected against what is taking place in the real world in a similar way as scientific idea is tested.

4. RESEARCH METHODOLOGY

The goal of this study was to explore the use of technology by teachers in the teaching and learning of mathematics at senior secondary schools in Gaborone. The study was guided by the following research questions:

Research Question One: What are teachers' attitudes toward the use of technology in mathematics?

Research Question Two: How do secondary school teachers use technology in mathematics lessons?

Research Question Three: What challenges do secondary school teachers encounter when integrating technology in mathematics lessons?

This chapter describes the methodology of the study. The chapter comprises the following sections: Research Design; Research Method; Population and Sample; Instrumentation; Data Collection Procedures; Ethical Consideration; and Data Analysis Procedures.

4.1. Population and Sample

The study involved mathematics teachers at public senior secondary schools in the city of Gaborone. There are four public senior secondary schools in Gaborone namely; Ledumang, St. Joseph College, Naledi and Gaborone secondary schools. The population contained a total of about 60 mathematics teachers from the four public senior secondary schools in Gaborone (Ministry of Basic Education, 2021). The study was limited to Gaborone only because of time and financial constraints.

4.2. Sample

The study involved two (2) out of four (4) public senior secondary schools in Gaborone which constitute 50% of the public senior secondary schools in Gaborone. Purposive sampling was used to pinpoint two schools from the four (4) public senior secondary schools in Gaborone as well as to select the teachers as participants in the study. Mikalef et al. (2019) define purposive sampling as “a non-probability method in which the researcher selects participants based on personal judgement about which ones will be more informative and as such, it is sometimes called judgmental sampling” (p. 739). Only two schools namely Naledi senior secondary school and Gaborone senior secondary school were chosen.

Ten (10) mathematics teachers from the two chosen schools were selected to participate in the study using purposive sampling. Ten (10) mathematics teachers which formed about 16.7 % of the population of teachers was made up of five (5) female and five (5) male teachers. The researcher trusted that the sample was large enough to permit generalizability in Gaborone. Belotto (2018) stated that a sampling fraction of between 10 – 20% of the total population is acceptable in descriptive research.

4.3. Instrumentation

The instrument used for data collection in the study was interview protocol. This was found appropriate because the study was a descriptive survey design. According to Lemenkova (2019) descriptive survey is one of the best methods used in collecting original data for describing a population too large to observe directly and like many other methods this is done through the help of interview protocol. Interviews were conducted with the selected teachers.

4.4. Interviews

A semi-structured interview technique was used in this study to convey discussions that would produce valuable data that could be utilized in qualitative analysis (Belotto, 2018). Semi structured interviews offered participants permission to freely express their views (Lemenkova, 2019) and to dominate the flow of topics.

A total of ten (10) interview questions for this study were built using the previous studies and surveys related to this one. Both English and Setswana interview guides were prepared and the respondents were given a choice to decide the language they were comfortable with.

4.5. Validity of the instruments

To validate items of the instrument, the interview instrument was presented to the colleagues to assist on checking its appropriateness in collecting data, its significance to the study, the suitability of the language used and precision of items (face validity technique). Following the face validation process, some contents were revised and corrected in order to get rid of any vagueness.

A pilot study method was utilized to ensure the validity and reliability of the instrument. A pilot study helped the researcher to identify the deficiencies in the data collection instrument and probable difficulties that may be faced during data collection (Leung, 2015). The pilot study was carried out at Ledumang senior secondary school, and the school was not be included in the main study. Five teachers participated in the pilot study. The teachers took part in the interview session. The pilot assisted the researcher to find any ambiguities in the items. The data gathered from the pilot study was analyzed using the processes described in the data analysis section below, and the results were used to modify the interview questions.

4.6. Reliability of the instruments

The test-retest strategy (Lemenkova, 2019) was used to ensure reliability of this study. To measure this, the researcher asked some participants (pilot participants) to take part in the interview. Then the same participants repeated responding to the interview questions after five days. This data was finally analyzed using the qualitative procedures described in the data analysis section below and the results were used to modify the interview questions.

4.7. Ethical consideration

The researcher requested for permission to collect data from schools from MOBE. Afterwards permission was then requested from the director of South East regional

education office under which the sampled schools fall. The researcher then asked for permission from the school heads at the respective schools before talking to mathematics senior teachers. Consent of the participants was requested as well. Participants were assured that information collected from them will be confidential and they were guaranteed anonymity.

4.8. Data Analysis Procedures

Data analysis procedures involved the qualitative method to find out their attitudes toward the use of technology in mathematics and how they use technology in mathematics lessons. This analysis took place in three stages. First, interview transcripts from the sound recorder were reviewed numerous times to check recurring regularities (Parameswaran, Ozawa-Kirk, & Latendresse, 2020; Belotto, 2018). The researcher highlighted the quotes from the interviews that were relevant and useful to the study. The researcher went back and forth along transcripts until consistent and distinct categories emerged, using the constant comparative method. The researcher labeled the categories, coded the transcripts and partitioned the labeled folders that represented each category. Secondly, the coded interview data was merged and a table was created to compare various coded interviews. Finally, the categories were combined until themes solidified.

5. RESULTS

5.1. Response rate

A total of 10 mathematics teachers were sampled in the study. All the 10 teachers sampled for the interview responded, representing a response rate of 100%.

5.2. Teachers' Use of Technology in Mathematics Lessons

This section determined the ways in which secondary school teachers use technology in mathematics lessons. The two emerging themes from the teachers' interviews were: Using technology as a teaching tool and the use of social media to share ideas with other teachers.

5.2.1. Using technology as a teaching tool

Most teacher interviewees noted that they mainly used technology as a tool which helps them complete tasks and activities easier. The most frequently used mathematically-related tools by the participants are calculators and computer software. One participant stated that:

Calculator technology is easily accessible in most homes and classrooms,

including basic four-function calculators and scientific calculators. Calculators offer a deeper understanding of math topics. When students are able to use a calculator, their basic skills in mathematics increase. When I teach my students some topics using calculators, their views on mathematics are more positive than working without a calculator. For example, my learners are confident when writing paper 2 exam than paper1 because the former requires the use of calculators while the latter strictly prohibits the use of calculators.

Most participants indicated that they frequently used GPS, word processor and spreadsheets as computer software tools. One participant mentioned that "I prefer using GPS because it enables our students to visually see the mathematics being taught." The other interviewee emphasised this point by saying, "mostly I use GPS in transformation geometry (reflection, translation, rotation) and graphing various functions." The other one noted "the use of GSP provides my students with greater control over their learning; lessons become student-centred and experimentally-based rather than teacher-driven." The results indicate that most of the interviewees used word processing to prepare departmental meeting minutes and set tests and examinations. They preferred the use of spreadsheets to store student marks and when teaching mathematical topics such as statistics and percentages.

5.2.2. The use of social media to share ideas with other teachers

All the participants talked exceptionally profoundly of social media, particularly WhatsApp and Facebook and regarded them the foremost valuable resource for picking up innovative information. The shared items can be in the form of audio, video, photo or document file. One participant elucidated that the greater part of the exercises that she prepared for students arrived from thoughts she saw on WhatsApp groups. She added that, "numerous educators will exhibit their math questions and the various open critical thinking solutions they are utilizing in their classrooms or share helpful applications, which I am thankful of." The other participant shared the same sentiments and acknowledged WhatsApp as the asset liable for the entirety of the information she had in regards to mathematics teaching strategies. Most participant talked about their love for "Facebook and WhatsApp chats" which are discussions that happen between mathematics teachers almost every night on various topics related to education. They depicted these talks as their road for teaming up and offering thoughts to other teachers and supporting and gaining from one another.

Albeit an incredible asset, one interviewee accepted that a great deal of teachers doesn't draw in with social media on the grounds that they don't comprehend its instructive esteem or don't have time, which he comprehended as there never is by all accounts enough time in a teacher's day. With this stated, he clarified that if an instructor is keen on learning through Facebook and WhatsApp chats, they don't

necessarily need to be actively online at all times. In the event that a teacher misses a chat, they can without much of a stretch search all of the archived chats. All participants implied the idea that with social media, there is no need to “reinvent the wheel.”

5.3. Teachers' Attitudes toward the Use of Technology in Mathematics

This section determined teachers' attitudes toward the use of technology in mathematics. The two emerging themes from the teachers' interviews were: Effective use of technology and Technology integration is valuable in mathematics classroom.

5.3.1. *Effective use of technology*

Most participants believed that technology offers both mathematics teachers and students a way to effectively and efficiently work more on tasks and activities. They felt that the use of technology encourages teachers to be more organized and to modify and update instruction more quickly. Participants believed that technology could support thinking processes, stimulate motivation and self-esteem, promote equity, prepare students for the future, support changes in school structure, and explore technology capabilities. They perceived technology as a resource that benefits the teacher in areas such as planning, organizing, monitoring and evaluating procedures and processes that rely on availability of precise and timely information. Below is an excerpt from one participant:

I believe that effective technology integration is attained when students are able to select technological tools to help them obtain information in a timely manner, analyze and synthesize the information, and present it in a professional way. This means that technology must be an essential part of how the classroom functions in terms of accessibility like in any other classroom learning tools. This evidently informs us that technology has become a key component of our educational system.

5.3.2. *Technology integration is valuable in mathematics classroom*

Participants in this study desired to access the specified technologies with a clear understanding of their impact in mathematics teaching and learning. The participants noted that incorporating technology into mathematics classroom is valuable, even though the technological tools were not always available. All participants comprehended the significance of having the technology readily accessible whether at home or school. They emphasized that technology is required for survival in everyday life. As indicated by one participant, students have an advantage when mathematics teachers integrate technology since “it helps students' to be technologically proficient.” The other participant proclaimed, “Technology enhances

exposure to different learning strategies.” All the teachers interviewed believed that technology assists students to improve their mathematics performance and makes learning curriculum standards more thrilling. They stressed that the advantage of technology integration is that it makes learning become interactive.

Most participants asserted that cell-phones, when used correctly, can flawlessly facilitate the activities of learning and teaching in interactive classrooms. According to one participant:

Even though mobile phones are banned in a lot of schools, they perform an important role in teaching and learning. With mobile apps and the internet at their fingertips, teachers and students are now using phones as clickers to answer questions, providing feedback on student progress, and also to document labs, collaborate on group projects and capture teachers' notes.

5.4. Challenges Encountered by Teachers when Integrating Technology in Mathematics Lessons

This section presents challenges encountered by teachers when integrating technology in mathematics lessons. The six emerging themes from the teachers' interviews were: Lack of technological resources affects learning; Insufficient access; Scarcity of time; Insufficient skills and competencies; Training necessity and Curriculum development.

5.4.1. Lack of technological resources affects learning

All participants were equally concerned about lack of access to technology outside the classroom by students. One participant remarked, “Technology in a mathematics classroom is good, but if it's not available then becomes useless,” and the other stated, “majority of students don't have computer or Internet access when they are home.” They noted that it is not helpful for an educator to plan for a lesson attempting to use technology only to find that the material is unavailable or limited. Without adequate hardware, software, internet access, and the like, teachers and media specialists may find it difficult to truly integrate technology. Shortage of technological equipment for teaching mathematics was a serious concern for all the interviewed participants. They stated that there were no computers or computer-related devices in their classrooms. Lack of computers in classrooms, as confirmed by one participant, is verified in the following quote:

We don't have any computers in the classrooms. The computers are only found in the computer lab, and sometimes in the staffroom or the office of the principal, but not in the classrooms. Unless, if a teacher brings his own laptop for a certain lesson.

The participants' robust criticisms of the absence of computers in the classrooms and their fervent requests for computers in the classrooms summed up the situation of classrooms with respect to technology integration of computers in mathematics education in these schools.

5.4.2. Insufficient access

Participants highlighted lack of access to technology as a barrier because when the schools have insufficient funds and inadequate resources then technology integration becomes meaningless. "Even the library, which one could have thought to be the second most technologically dense area of the school after the computer lab, has a limited access", noted one participant. Students are only allowed to enter the library during their scheduled class visit time. One participant emphasized this point by the following excerpt:

the library does not have enough technological resources, the books are very few and outdated. It does not even have magazines, only the Botswana daily newspaper is available. There are only two working computers inside the library which are used by staff.

Participants, nevertheless, specified that they had access to the computer labs, even though it was limited because some learners play games on the computers. The fact that some students play games in the lab forced the computer coordinators to come up with tight rules to be applied in the lab.

5.4.3. Scarcity of time

Participants believed that integrating technology into a mathematics classroom definitely consumes a lot of time, particularly when it must be aligned with the objectives of the syllabus. Teachers are expected to spend hours browsing websites, gaining familiarity with hardware and software, and informing themselves with numerous programs. Teachers who are eager to work extra hours to do this are depressed because they are not paid any overtime allowances due to lack of funds. Over and above the time consumed teaching the material that will be assessed, the absolute quantity of time that must be devoted to the assessment procedure itself can act as a challenge. Standardized testing is normally done frequently in a year, consuming a lot of time, thus reducing even more chances to integrate technology. Teacher workload tightens the schedule for teachers hence a barrier to professional growth. This was emphasized by one participant in the below excerpt:

School timetable is so congested in such a way that teachers volunteer for afternoon, evening, weekend and vacation lessons. This tightens their schedule such that even if they were to plan for technology integration workshops, time becomes so limited for them.

The above excerpt also reveals another challenge that mathematics teachers are overwhelmed with work outside working hours which they are not paid to do.

5.4.4. Insufficient skills and competencies

Most respondents indicated that, even on the availability of appropriate resources, teachers usually tussle with an insufficient knowledge of specific technology and technology- strengthened pedagogy to use in mathematics classrooms. They felt that technology can be an alarming notion for many teachers, especially those who did not grow up operating computers or internet. One of the respondents had the following to say:

When I discover a particular technology to be confusing, it becomes unlikely for me to consolidate it into the topic of the day. Lack of training to operate specific technologies and lack of time to discover updated features are serious dissuasions for us as mathematics teachers to integrate technology into the classroom.

5.4.5. Training necessity

Participants indicated that they needed a series of in-service workshops and training to acquire basic technological knowledge (computer use and application) and basic technological content knowledge (using technology in accessing subject content knowledge). They believed that obtaining these categories of knowledge on top of knowledge of teaching subject is essential but for effective use of modern technology incorporation in mathematics teaching. One participant alluded that:

Using technology innovatively in mathematics education as desired in the 21st century classroom requires teachers to possess good technological pedagogical knowledge and the skills of its application in teaching. This would enable teachers to gain the competence required in teaching in 21st century learning environment. The mathematics teachers' lack of sufficient ICT skills and competencies together with their limited knowledge of technology use in the classrooms is a serious concern and calls for more training.

As a way of reducing the challenge of teachers' lack of knowledge and skills of technology use, participants expressed the significance of training programs that will offer them opportunities to integrate technology in the teaching and learning sessions. The following excerpt from one participant shows the need for training, "they must cater for computer literacy training, I guess the introduction of technology integration courses for us will help." Most participants felt it could be effective if each school had individuals within the building for technology integration training instead of having an outside person train them. They believed that if a teacher in the school building is well-

versed on using technology to enhance mathematics lessons, then this teacher could assist others to promote enhanced integration.

5.4.6. Curriculum development

All the interviewees pointed out that there is need to redesign the curriculum that would enable students to use technology in mathematics instruction in the form of a continuous assessment. They stressed that the curriculum should introduce practical assessments that allow students to apply technological skills in some mathematics topics. One respondent noted that:

I think that the curriculum should be revised and permit us to teach learners practical sessions using technological tools which contribute to their continuous assessment just like they do in science labs. This will help learners to pay more particular attention knowing that the sessions are part of their exam marks.

6. CONCLUSION

The findings of the study indicated that students and teachers use technology for different purposes both in mathematics instruction and outside the classroom. The results showed that teachers demonstrated positive attitudes toward the use of technology in mathematics education. The findings also showed that teachers are willing to integrate technology in mathematics education despite the challenges that they encounter. These challenges include lack of technological resources, insufficient access, scarcity of time, insufficient skills and competencies, inadequate training as well as lack of curriculum development.

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