Embracing Mobile Learning Technology-Based Innovations to Improve Mathematics Teachers' Pedagogical Orientations During COVID-19 and Beyond

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Abstract: During the COVID-19 era, remote mathematics curriculum delivery was a challenge to many teachers. Teachers struggled to effectively integrate virtual environments in order to improve their Technological Pedagogical Orientations (TPO). This study examined South African teachers' perceptions towards incorporating Mobile Learning Technology-Based Innovations (MLTBI) to remotely facilitate quality delivery of mathematics as construed by the Curriculum and Assessment Policy Statement. It also determined the degrees of TPO and hurdles to integrating MLTBI among mathematics teachers in the wake of COVID-19. The study adopted a mixed method approach and a descriptive survey research design. Fifteen out of thirty-two senior secondary school Mathematics in-service teachers in one Circuit Manager Cluster, participated in the study. TPACK and TAM theoretical frameworks underpinned the study. The conclusion was that usage of cell phones in mathematics classrooms has an impact on both teaching and learning processes. Findings were that teachers might be classified as either innovative or instrumental. Innovative teachers make transition from traditional chalk and talk to innovative teaching. Altered teaching methods alter classes to make use of the enhanced benefits that MLTBI may provide. Instrumental teachers used the device as a "glass book." The distinction between the two groups' ramifications is in terms of mathematical learning outcomes. In the wake of COVID-19, the advent of MLTBI signals a shift in Mathematics curriculum delivery, as the devices create interactive, media-rich, and interesting new environments. Introduction of technological and pedagogical support to help teachers comprehend MLTBI's full potential in education is recommended for policy makers.

Keywords: Mobile Learning Technology-Based Innovations, Mathematics, Technological Pedagogical Orientations, COVID-19, 21st Century skillset

1. Introduction

Development of competencies for 21st Century skills are gathering increasing attention as a means of improving teacher instructional quality, a key challenge in bringing about desired improvements in mathematics education lies in the lack of context-specific understanding of teaching practices and meaningful ways of supporting teacher professional development (Kim, Raza & Seidman, 2019). Hedding, Greve, Breetzke, Nel and Van Vuuren (2020) claim that surviving in the 21st Century [and in the wake of the COVID-19 pandemic] requires a sound education which offers a wide perspective on issues of global awareness, environmental literacy, digital literacy, and civic competence.

In March 2020, economic activities in South Africa were forced into an induced lockdown in which all operations, including face-to-face teaching and learning, were halted abruptly. The effect was compounded for rural schools that did not ordinarily possess the capacity to provide alternative teaching and learning systems (Hedding *et al*., 2020). Mncube, Olawale and Hendricks (2019) assert that prior to the advent of the pandemic, there had already been calls for the education system in South Africa to embrace technologies as a response to the fourth industrial revolution (4IR). Furthermore, Gravett (2012) argues that appropriate technological pedagogical choices to enhance the quality of mathematics teaching, is an aspect that is questioned in literature as universities are still criticised for their unsatisfactory attempts to prepare teachers for the classroom, thus producing incompetent teachers.

2. Literature

2.1 Trajectory of COVID-19 in South Africa

The South African government decided to declare this pandemic a national state of disaster under

the Disaster Management Act (South African Government, 2020), which instituted a national lockdown, when the first case of COVID-19 was confirmed in South Africa. While there were significant attempts made by the education sector to continue teaching and learning during this difficult period, the bulk of learners were forced to rely entirely on their own resources to continue learning remotely via various platforms. Teachers had to adapt to new pedagogical concepts and remote lesson delivery in which many had no formal training. Learners in the most marginalised communities, who did not have access to digital learning resources or lacked the resilience and engagement to learn on their own, were at risk of falling behind (Schleicher, 2020).

2.2 Impact of COVID-19 on Mathematics Education

The pandemic has shown the flaws and shortcomings of the current educational systems. Rakes, Ronau, Bush, Driskell, Niess and Pugalee (2020) posit that educational [Mobile Learning Technology-Based Innovations (MLTBI)] could improve learner performance in these crucial areas if implemented in a way that fosters meaningful and effective use of technology in the classroom. However, Saal, Graham and van Ryneveld (2020) assert that professional development in this area is required because South African teachers are unable to integrate [MLTBI] into their classrooms effectively.

In the wake of the COVID-19 pandemic and the challenges of 4IR, Sincuba and John (2017) posit that research must guide policy and drive transformation in order to build a mathematically and scientifically literate community for South Africa to engage in the technologically developing global village. Spaull and Kotze (2015) concur with Sincuba (2016) who attests that few studies have been conducted in developing countries such as South Africa to assess teachers' attitudes towards integrating MLTBI in 21st Century classrooms and how the teachers' experiences can be used to identify best practices for integrating MLTBI to improve educational outcomes in mathematics. This assertion makes it evident that there is still much to understand about how pedagogical approaches of mathematics teachers and their use of MLTBI for teaching and learning are related. For students and teachers in underdeveloped nations, the availability of virtual classrooms and remote teaching and learning during the COVID-19 era has presented many obstacles.

2.3 21st Century Teaching Skills

The breadth of skills required for quality student learning, and concomitantly quality teaching, call for essential competencies and skills beyond literacy and numeracy. This 21st Century skillset is understood to encompass a range of competencies, (critical thinking, problem solving, creativity, meta-cognition, communication, digital and technological literacy, civic responsibility, and global awareness) (Dede, 2010). The 21st Century pedagogies have developed the capacity to allow learners and teachers, to discover and master content, create and use new knowledge (Lazarov, 2018) to counteract the fourth industrial revolution's (4IR) challenging world of work. This corroborates with Fullan and Langworthy (2014), who asserted that developments have profound implications for curriculum, learning design and assessment. Sikhakhane, Govender and Maphalala (2020), propose an evaluation of these developments in terms of enhancing learning acquisition and developing critical and emotional intelligence, computational and communication competencies and dexterity in the 21st Century generation. These developments are more important in developing country contexts (South Africa included), where substantial lack of improvements in learning outcomes has suggested that the task of improving instructional quality is urgent.

2.4 Mathematics Teachers' TPACK in the Wake of COVID-19

In developing, a technology based learning environment to improve teaching, one has to consider a number of pedagogical imperatives (Mji, 2021). Alexander (2001) cited in Mji (2021) considers pedagogy as comprising of teachers' ideas, beliefs, attitudes, knowledge and understanding about the curriculum, the teaching and learning process and their students, and which impact on their teaching practices. Tarling and Ng'ambi (2016) advance that a focus on teacher training is needed to help improve the learning deficit in South Africa. If South Africa is to participate in the technologically advancing global village, it is imperative that research should inform policy and drive transformation in order to create a mathematically and scientifically literate society (Sincuba & John, 2017). It is also true that the positive and negative effects of cell phone devices on humans, particularly in the classroom, are within the field of interest of social sciences, as are those of all new technologies.

Even with the Department of Education engaging teachers in numerous training and upskilling professional development initiatives, teachers' practices seem to remain fairly unchanged and continue with the use of traditional and lower order thinking pedagogies that do not effectively utilize technology for teaching and learning (Tarling & Ng'ambi, 2016). Accordingly, the TPO of teachers who naturally have the highest opportunity to monitor learners' progress on cell phone devices that are considered likely to affect learners in social, psychological and learning-related terms, gain importance. Teachers' TPO form a reference to teachers' capacity to utilize this innovation within and outside of the classroom for teaching purposes. These concomitant changes put a very high demand on mathematics teachers and as such impact on educator behaviour. In the bid to teach for mathematical proficiency, the teacher needs to be intimately familiar with the content of the topics being taught, as well as how his/her learners are likely to interact with that content. It also means that the teacher needs to be knowledgeable about the trajectory of the topics being taught, thus bringing to the fore what Shulman (1986) referred to as teacher's subject matter knowledge, curriculum knowledge and pedagogical content knowledge. Furthermore, the mathematics teacher needs to know that in his class of diverse learners they are not all going to learn in the same way, hence the need for 'differentiated learning approach'.

While there has been an increasing focus in the literature on the use of mobile devices such as cell phones for teaching and learning (Ali & Irvine, 2009), the majority of the studies appear to make assumptions about the relative ease in which such innovations could be incorporated into the classroom (Buck, McInnis & Randolph 2013). Clayson and Haley (2012), attest that only a few studies have considered psychological, pedagogical and administrative barriers to the use of such technologies in schools and in the minds of the teachers. Specifically, few studies have been conducted in developing countries such as South Africa to assess teachers' TPO towards using cell phones in the mathematics classrooms and how the teachers' experiences can be used to identify best practices for integrating MLTBI in the wake of COVID-19 pandemic. Despite the abundant research literature regarding the benefits of cell phone usage among learners, a gap exists in terms of the teacher who happens to be an important dimension of a school's instructional capacity. Furthermore, since much of the research often occur in developed countries (Ali & Irvine, 2009) and institutions of higher learning, the degree to which findings can be generalized as "one-size fits-all" is of concern.

Kafyulilo (2012) asserts that to date, little research has explored the views of teachers or the actual educational contexts in which they teach on the use of mobile technology devices in the classroom. Some researchers have raised some concerns, including evidence that texting during classes negatively impacts learning and distracts other learners, and issues such as learners using cell phones for sex messaging or other inappropriate activities (Clayson & Haley, 2012). While benefits are commonly reported in the literature, these studies lack investigations on the drawbacks and challenges faced by teachers in trying to incorporate MLTBIs such as cell phone devices for Mathematics teaching and learning. Through this study, the researchers aimed to shade some light in this uncharted area of research. In this respect, it was therefore imperative to conduct a survey research to assess the attitudes among teachers towards MLTBIs and generating sustainable initiatives for the 21st Century classroom.

3. Theoretical Framework

The following theoretical frameworks constructed the theoretical Framework for this study.

3.1 The Technological Pedagogical and Content Knowledge (TPACK) Framework

This study was underpinned by the TPACK framework developed by Shulman (1986) and Mishra and Koehler (2006). The TPACK framework describes how teachers can strategically integrate virtual environments in their teaching to create meaningful learning experiences. The TPACK framework consists of three primary knowledge domains (Koehler, Mishra, Kereluik, Shin & Graham, 2014). Firstly, the technology knowledge (TK), associates teaching and learning with the incorporation of knowledge of traditional analogue and digital technologies. A teacher with TK understands how MLTBI integration can improve teaching methods and enhance learners' content knowledge; how MLTBI tools fit into teaching and learning, but also in learners' daily life; and how to use MLTBI. Secondly, the pedagogical knowledge (PK) domain relates to knowledge of teaching strategies to support learner understanding. Lastly, the

content knowledge (CK) domain describes the disciplinary knowledge a teacher conveys to learners.

3.2 The Technology Acceptance Model

The Technology Acceptance Model (TAM) developed by Davis (1989) is one of the most popular research models to predict use and acceptance of information systems and technology by individual users. The TAM posits that individuals' behavioural intention to use an Information Technology (IT) is determined by two beliefs:

- **Perceived Usefulness**, defined as the extent to which a person believes that using an IT will enhance his or her job performance.

- **Perceived Ease of Use**, defined as the degree to which the prospective user expects the Target system to be free of effort.

4. Statement of the Problem

The South African education system has had inherent systematic dysfunctionalities prior to the COVID-19 pandemic. A study conducted by Mji (2021) revealed that between 2014 and 2018, 63% to 68% of Grade 12 learners did not achieve a mathematics mark that allowed them to register at a university. Emergent unique problems wrought by the pandemic have compounded the problem especially for rural South African schools. Closing the academic gap caused by the pandemic in the last two years will be a tall order. Research-based classroom instructional strategies and effective forms of professional development should aim at reducing the variations in the teaching practice to the point that every teacher ensures that no child is left behind. This study addressed challenges faced by South African Mathematics teachers towards proficiently embracing and integrating MLTBI to improve educational outcomes in Mathematics in the 21st Century classroom and in the wake of COVID-19 pandemic.

5. Research Questions

- What Subject Content Knowledge do Mathematics teachers hold for effective curriculum delivery?

- What are the teachers' attitudes towards integrating technology in teaching and learning of Mathematics?

- What are the barriers to integrating MLTBI inform the design of CPTD programmes for the 21st Century Life Long Learner and in the wake COVID-19 pandemic?

6. Purpose of the Study

This study explored the TPO among Grade 10-12 teachers towards integrating MLBTI to improve educational outcomes in Mathematics. Teachers' TPO were explored in relation to cell phone educational usage during Mathematics classes in the wake of COVID-19. This study further reported on mathematics teachers' levels of TPACK and barriers to integrating MLTBI in order to inform the design of Continuing Professional Teacher Development (CPTD) programmes for the 21st Century learner and in the wake COVID-19 pandemic. The authors argue that mathematics teaching in South Africa could improve by providing well-designed CPTD programmes that address mathematics teachers' current levels of TPACK and specific MLTBI-integration barriers.

7. Significance

The study is important because it describes the pedagogical methods that mathematics teachers employ to design their teaching actions with MLTBI in the wake of COVID-19 pandemic. In the context of the 21st Century skills and the wake of COVID-19 pandemic, researchers are looking into mathematics teachers' experiences towards integrating MLTBI to improve remote teaching and learning.

8. Methodology

8.1 Research Approach

The study adopted a mixed method approach which was apt for the research since it concerns both the statistical data and descriptions of thinking exhibited by the participants' answers to specific questions (Creswell & Creswell, 2018).

8.2 Research Design and Sample

This study used a descriptive survey research design which describes the opinions of the in-service teachers regarding their TPO on integrating MLTBI for teaching and learning in the wake of the COVID-19 pandemic. The design involves the collection of data as presently constituted to describe a phenomenon,

without a conscious effort to control any variables (Creswell & Creswell, 2018).

The adopted descriptive survey research design enabled the researchers to measure and assess the level of TPACK of Grades 10 to 12 mathematics teachers. This research design was employed to allow the researchers to explore teachers' views about MLTBI-integration barriers affecting teaching and learning. The researchers' questionnaire was grounded on the revised framework on teacher behaviour by Van der Sandt (2007). See Table 1.

This study was contextualised in Amathole East district, Eastern Cape Province, South Africa. In terms of performance at Matric level, Eastern Cape has been among the low performing provinces in the country. Every year, Eastern Cape receives large budgets towards educational programmes. Due to this large financial investment, the province issued most of its schools with laptops and tablets and as such it was expected that it should include many schools that have access to resources which include virtual environments infrastructure. In the selected district, JENN Training and Consultancy in collaboration with the Eastern Cape Department of Basic Education further beefed up the availability of technological devices to improve virtual environments for teaching and learning of mathematics and science in schools. In view of these efforts, authors assumed that mathematics teachers in schools might have received more training opportunities in the use of MLTBI than teachers in other districts. Fifteen participants were purposively selected from a population of thirty-two mathematics teachers teaching grades 10, 11 and 12 to participate in the survey. They were selected according to the following criteria:

1. All teachers had to teach mathematics in grades 10, 11 and 12.
2. Mathematics teachers were from public schools.
3. Schools were located in Dutywa Circuit Manager Cluster, Amathole East district, Eastern Cape Province, Republic of South Africa.
4. Participation was voluntary.

This sample was requested to complete a questionnaire which was then used to assess the level of TPO of the participants towards the integration of MLTBI for mathematics remote teaching and learning in the wake of COVID-19 pandemic. By examining the differing experiences, skills levels and opinions of participants, the researchers sought insight into the varying levels of teachers' TPACK. Descriptive statistics (frequencies and percent) were used to analyse the data from Likert scale type of questions while thematic analysis (Clarke & Braun, 2013) was used to analyse data from the open-ended questions.

8.3 Data Collection Instrument

The questionnaire used in this study was adapted from the questionnaires developed by Schmidt *et al*. (2009) and Chai, Koh and Tsai (2011). The questionnaire consisted of four sections. Section A, surveyed participants' biographical information, Section B, consisted of eight items that dealt with their digital literacy and devices for virtual teaching and learning, Section C, participants' PCK competences in integrating MLTBI for teaching and learning mathematics. Section D, included 26 Likert scale type items with a four-point scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) to assess participants' levels of TPACK according to the seven primary knowledge domains, namely **5.1**: TK (items 1-6), **5.2**: CK (items 7-8), **5.3**: PK (items 9-14), **5.4**: PCK (items 15-16), **5.5**: TPK items 17-19), **5.6**: CK (items 19-21) and **5.7**: TPACK (items 22-26) (De Freitas, 2018).

Table 1: Revised Research Framework on Teacher Behaviour

Teacher Behaviour		
1. Teacher knowledge	2. Teacher views and beliefs	3. Teacher attitude
1.1 Curriculum knowledge	2.1 Teaching of subject	3.1 Subject
1.2 Subject content knowledge	2.2 Learning of subject	3.2 Students
1.3 Pedagogical content knowledge	2.3 Nature of subject	3.3 Teaching of subject
1.4 Student learning	2.4 Students as learners	

Source: Van der Sandt, 2007

8.4 Validity

An overview of literature focusing on the TPACK framework and CPD of mathematics teachers contributed to the theoretical validity of the study. The questionnaire was based on two standardised TPACK surveys, which had been previously validated by the developers. However, due to changes in the number of items used and the wording of some items, an exploratory factor analysis (EFA) was conducted to assess the internal structure of the questionnaire, thus validating the extent to which the test items sufficiently match and exemplify the construct (Clark & Watson, 2019). The questionnaire was amended with regard to language and wording of items to make it more suitable for a South African context. Thereafter, the questionnaire was piloted with four mathematics teachers with regard to clarity, readability and terminology before being administered to the participants in the sample. The piloting process contributed to the coherence and consistency of the questions.

9. Reliability

The questionnaire was adapted for in-service mathematics teachers within a South African context from two standardised TPACK instruments, namely the Survey of Preservice Teachers' Knowledge of Teaching and Technology (Schmidt *et al*., 2009) and a TPACK survey developed by Chai *et al*. (2011).

10. Results and Discussion

From the sample of 15 participants, 8 (53,33%) were female while 46,67% were male participants. See Figure 1.

Emerging from Figure 2, the sample consisted of three ethnic groups, namely 11 black African teachers (73, 34%), 2 coloured (13, 33%) and 2 Asian teachers (13, 33%).

From Figure 3, the mean age of the sample was 40.5 years (standard deviation, SD = 12.1) with a range between 23 and 71 years.

Figure 1: Biographical Information

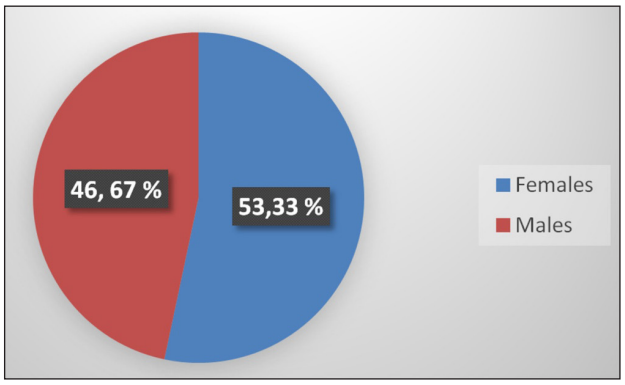

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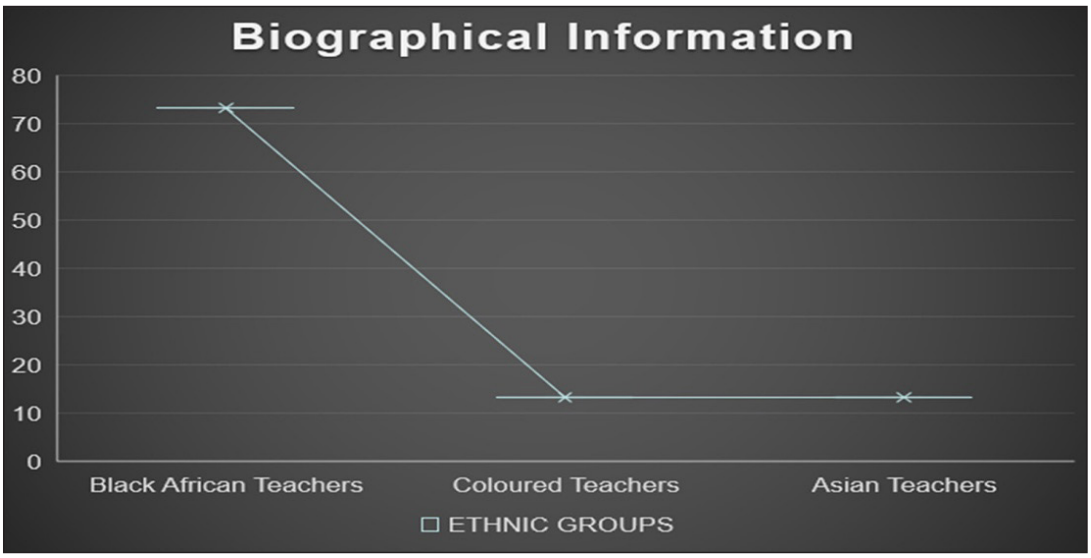
Figure 2: Biographical Information



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Emerging from Figure 4, all participants agreed or strongly agreed with statement 5.2, 5.4 and 5.7 and disagreed or strongly disagreed with statement 5.5. On statements 5.1, 5.3 and 5.6, some participants agreed or strongly agreed while others disagreed or strongly disagreed.

Figure 3: Biographical Information

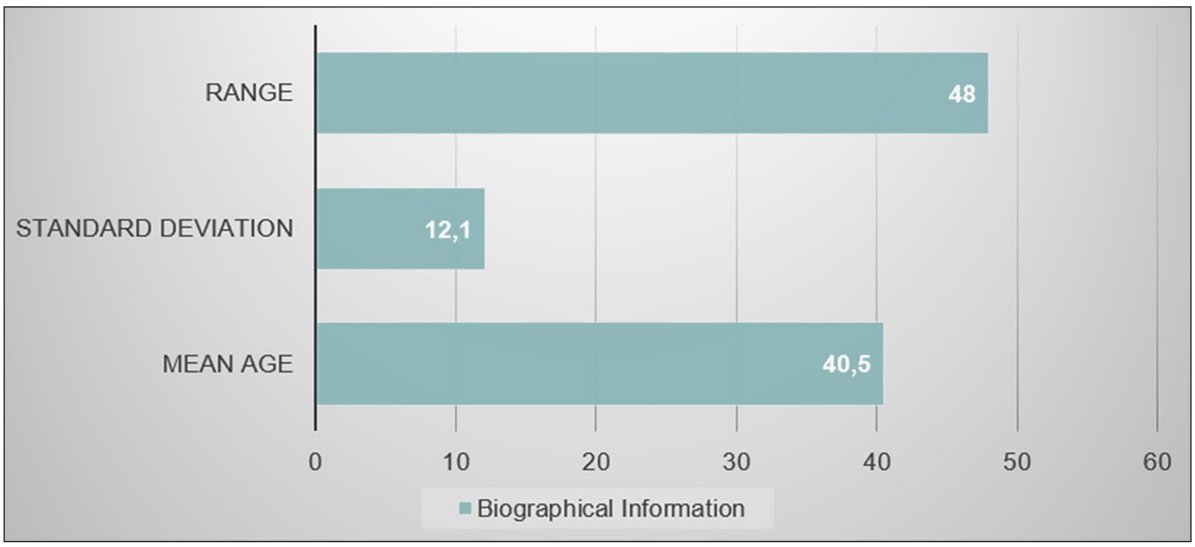

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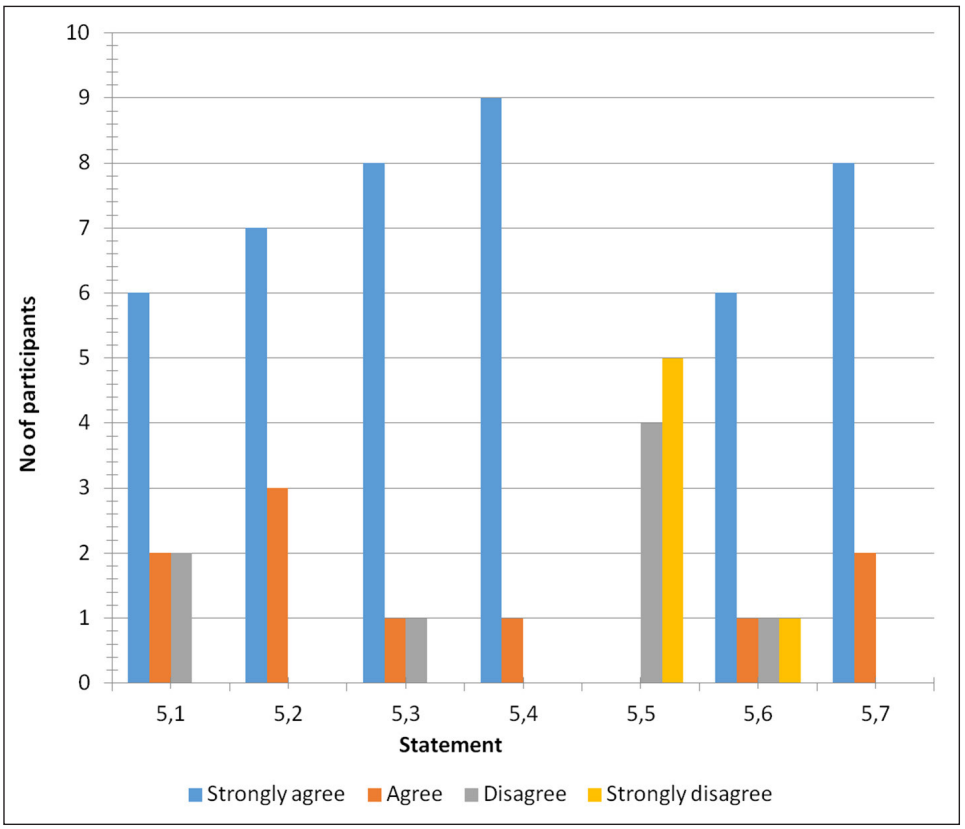
Figure 4: Teachers' Competences in Integrating Mobile Learning Technology-Based Innovations



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Emerging from Figure 5, there is a general disagreement by the teachers to the itemised statements. In Item 9.1, 90% of the participants did not agree with the statement that "the use of cell phones in teaching and learning of mathematics is interesting". Items 9.2 and 9.3, 80% of the participants did not agree that "designing of lessons with a cell phone was of interest to me" and "the use of cell phones has the potential of enhancing my pedagogical competency". In Items 9.4 to 9.6, 90% of the participants disagreed or strongly disagreed with the itemised statements. In Item 9.7, 80% of the participants were of the view that use of cell phone devices in the classroom cannot provide alternatives to problem-solving Mathematics.

Emerging from Figure 6, most respondents strongly agreed with the items under each theme. 100% of the participants strongly agreed that using cell phones for teaching and learning distorts learners'

Figure 5: Teachers' Responses to Impact of MLTBI in Teaching and Learning Mathematics

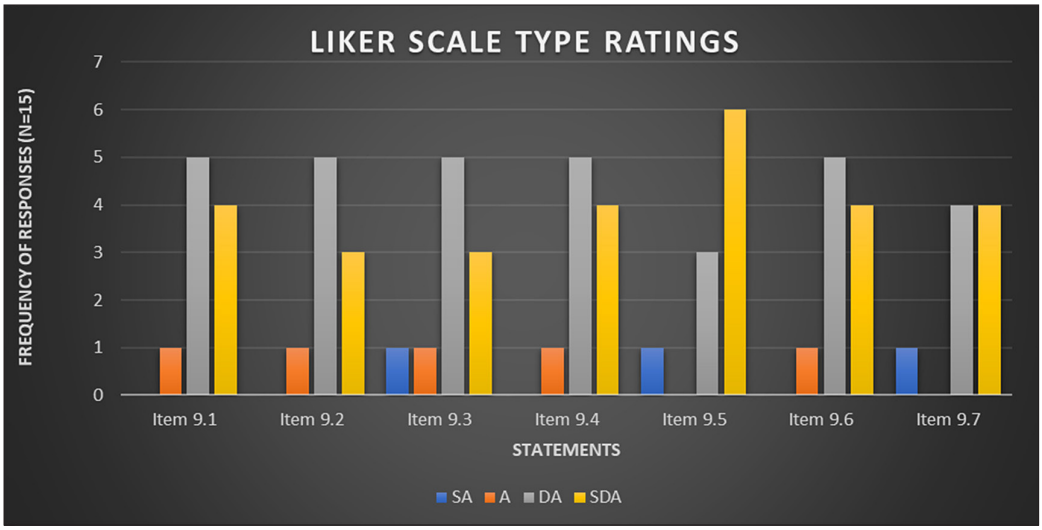

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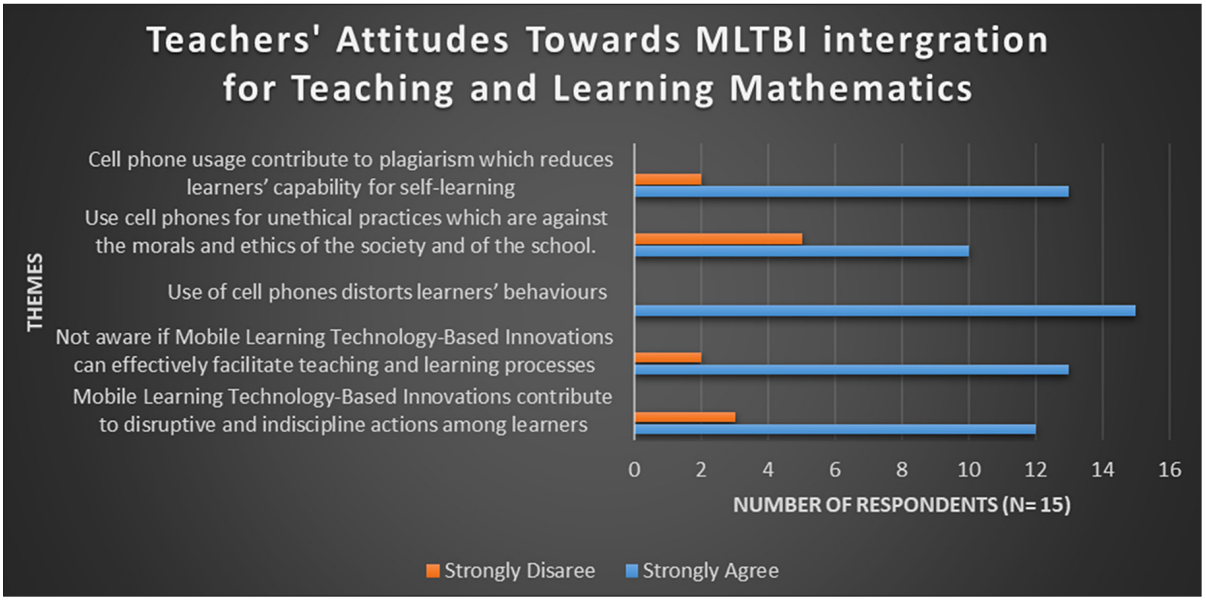
Figure 6: Teachers' Attitudes Towards MLTBI Integration for Teaching and Learning Mathematics



Source: Authors

behaviours while 33% strongly disagreed that unethical practices among learners are caused by cell phone usage. 80% of the participants strongly agreed that MLTBI to disruptive and indiscipline actions among learners.

11. Discussions

11.1 Administrative Issues

Regarding responses on teachers' attitudes towards Mobile Learning Technological-Based Innovations (Figure 6), it emerged that most respondents agreed with most statements. This is in concurrence with Hedding *et al*. (2020) who claimed that surviving in the 21st Century requires a sound education which offers a wide perspective of global awareness, environmental literacy, digital literacy and civic competence. However, all respondents disagreed with statement 5.5, which included ethical issues, mobile phone bans in schools and curriculum adaptations. The majority of the participants raised fears about the inclusion of cell phone devices in the classroom. Some teachers also argued that cell phones contribute to plagiarism which reduces learners' capability for self-learning. The findings are consistent with Lazarov (2018) who advanced that one particular critical challenge noted with regard to integration of mobile learning into the classroom is the prohibition of cell phone usage within schools, which may affect teachers' attitudes regarding mobile learning in their classes or prevent them from making any efforts to that end. Responses to statement 5.6 affirmed that the schools' geographical locations contribute to teachers' incompetency to integrate MLTBI. Schleicher (2020) concurs by stating that learners in most marginalised groups, who did not have access to digital learning resources or lacked the resilience and engagement to learn on their own, were at risk of falling behind. All respondents strongly agreed or agreed with statement 5.7 which indicated that subject specialization contribute to teachers' incompetency in integrating MLTBI aided programs in their teaching. In agreement, Tarling & Ng'ambi (2016) advanced that a focus on teacher training is needed to help improve the learning deficit in South Africa.

11.2 Pedagogical Issues

Emerging from Figure 5, most participants were of the view that lack of mobile learning technology devices in their respective schools contributed to teachers' incompetency in integrating MLTBI during the country's lockdown due to the COVID-19 pandemic. Participants further confirmed that lack of in-service training on integrating MLTBI for the 21st Century classroom was another attribute that contributed to the incompetence of teachers in integrating MLTBI in virtual mathematics classes. In concurrence, Foulger *et al*. (2013) asserted that teachers received minimal technological and pedagogical assistance from higher education institutions with regard to effective implementation of mobile learning in the classroom education. Another finding was that participants affirmed that teachers' ages and experiences contributed to their incompetency in integrating MLTBI aided programs during their teaching. In their research findings, Kim *et al*. (2019) confirmed that limited, unclear best practices regarding preparing teachers for the integration of mobile devices is a definite barrier.

11.3 Classroom Management

One prominent finding emerging from Figure 4, was that teachers were of the view that the use of cell phones distorts learners' behaviours as the majority of them do engage in some non-learning related activities, such as texting each other during class hours. The finding contradicted Mncube *et al*. (2019), who asserted that prior to the advent of the pandemic, there had already been calls for the South African education system to embrace technologies as a response to 4IR. Some teachers also reported that some learners actually used cell phones for flirting and watching pornographic contents which are against the morals and ethics of the society and of the school. Kim *et al*. (2019) asserted that teachers raised concerns about potential ethical issues such as cyber-bullying, privacy, archiving and record keeping, sharing classroom experiences and artefacts, parental and learner informed consent, and e-safety.

12. Conclusion and Recommendations

Findings revealed that although MLTBI has generally benefited learners during the pandemic era in developed countries, it is still a bone of contention among teachers in developing countries. Buck *et al*. (2013) concur that the findings in developing countries contradict the general implication in mobile learning literature that the use of mobile phones is inherently good and is easily integrated into the school context. Issues raised by teachers are clear contributory factors towards their unpreparedness to embrace cell

phone usage and the concept of MLTBI to enhance mathematics teaching and learning. Lastly, there appears to be general attitudes among Mathematics teachers that MLTBI are not for 'educational' purposes. The paper recommends the following:

12.1 Transforming Teacher Education Practices with Theoretically Sound Approaches

Teachers need to go beyond the MLTBI tools' potential to explore pedagogical benefits of mobile learning within the mathematics content areas. Embracing this change in education practices will help practising teachers realize the pedagogical advantages of MLTBI that may shift their perspectives toward the integration of MLTBI into 21st Century classrooms. While a number of studies presented the benefits of embracing MLTBI within field experiences, more research is needed to understand its unique applications as well as its impact on teachers' successful implementation of school-based practicums. To understand the sustained effect of MLTBI initiatives in mathematics education, teachers and researchers need to conduct longitudinal studies in the wake of COVID-19 pandemic and enacting pedagogical approaches to MLTBI within the 21st Century classroom settings (Kim, Raza & Seidman, 2019).

12.2 Investigating Additional Strategies for Mobile Learning Integration and Expanding Data Corpus on Cell Phone Usage and MLTBI Incorporation

Teachers may be assisted in developing classroom management strategies to minimize the so called 'bad smart phone' behaviours. Moreover, teachers may need support to identify appropriate, useful and relevant teaching activities that incorporate MLTBI. Research needs to investigate how different types of mobile learning projects, time requirements, and site contexts have an impact in the way teachers develop outcomes and how different types of planning, design, engagement, observation, reflection and assessment activities effect these outcomes. Based on the findings, it is also recommended that interested researchers expand the data corpus on MLTBI and establish its relationship to desired teacher outcomes, such as TPACK within MLTBI contexts and address issues endemic to teacher development and education in the teacher preparation phase.

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