Impact of Digital Content on Mathematics Teachers' Pedagogical Change: Experiences from Retooling of Secondary School Mathematics Teachers in Tanzania

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Abstract

This study assessed the ability of retooling digital contents to assist Mathematics teachers to handle the contents which were difficult and examined whether teachers had improved their pedagogical content knowledge. The Kirkpatrick and Kirkpatrick (2009) evaluation model was used to determine the impact of the digitized contents on teachers. Students and teachers were approached for interviews, classroom observations, and focus group discussions. Data analysis revealed that the retooling of multimedia content had an impact on raising the interest and motivation to teachers' teaching and students' learning. The study concludes that retooling contents assisted teachers to acquire adequate pedagogical content knowledge of teaching difficult Mathematics contents. The study recommends that retooling training be extended to all Mathematics teachers in the country.

Keywords: *courseware, monitoring and evaluation, multimedia, quality of teaching, short message services*

Introduction

Mathematics is a crucial subject to human life. It is a subject that is central to the transformation of human life through technological innovations. It is through Mathematics that science and technology education can be imagined in the whole aspect of transforming the national economy. Mathematics enables persons to increase their ability to reason and analyze abstract phenomena (Samwel, Mulenga & Angel, 2016). This leads to the transformation of abstract phenomena to achieve technological innovations. It is important to realize that Mathematics is important both for science and in addressing life problems (Ozdamli, Karabey & Nizamoglu, 2013). Charles-Ogan (2015) argues that, a country needs to critically focus on the transformation from a traditional economy to an innovative economy that is primarily based on the integration of Mathematics, science, technology, and engineering as the means of production. Needless to say, Mathematics is a prerequisite for these transformations to occur.

Despite the importance of Mathematics, there has been an outcry in the world on the high rate of failure in the subject. For instance, the study done in Zambia by Samwel et al. (2016) revealed that Mathematics is one of the core subjects that the students fail despite several efforts being put forward. Mathematical languages in some content such as in algebra, including word problems, have been mentioned to hinder the students' learning and assessment of outcome in the subject. In recent years, in Nigeria, for instance, 13 out of 20 major topics in the secondary school Mathematics curriculum are perceived by students as difficult topics including sequence and series, linear and quadratic functions, areas, volumes, statistics, logarithms, and circles (Bichi, 2018). Some of the reasons that hinder performance in mathematics, as observed some years ago in similar content in Tanzania, include the abstractness of the subject, incompetent teachers, inappropriate teaching and learning methods and lack of interest among students (Mtebe, Kibga, Mwambela, & Kissaka, 2015). This calls for the attention to rethink of the better ways of teaching Mathematics and reform the curriculum to allow more use of technology in teaching and learning (Charles-Ogan,2015) as well as improvement of pedagogical practices.

While the studies propose Mathematics to involve more hands-on activities (Samwel et al., 2016), other studies advocate the use of technology in improving teaching and learning and hence improved performance in the subject. Digital technology is advocated in Taleb Ahmadi and Musavi (2015) as a means of helping students to acquire information through various sources and promote sharing knowledge and skills among peers. Involving digital technology such as videos, animations and graphics in Mathematics would probably address the challenges of abstract nature of the subject, increase interest among students and hence improve performance. According to Saleh and Alias (2012), electronics learning (E-learning) and mobile learning (M-learning) facilitate learning regardless of geographical locations. The role of technology-supported education is to help a student to concretize the abstract concepts (Persico & Pozzi, 2011). Teachers in the study by Taleb, Ahmadi and Musavi (2015) observed that mobile technology increases motivation to learn Mathematics. The study further indicated that there is a direct and significant relationship between the utilization of mobile devices and students' motivation to learn Mathematics.

Mtebe et al. (2015) reported that less effort has been made to upgrade Mathematics teachers in pedagogy and subject content knowledge in Tanzania. As a result, students perceive Mathematics as one of the difficult subjects to be learned (Rameli & Kosnin, 2016). According to Pardimin and Huda (2018), teachers with an understanding of mathematical concepts are able to improve teaching and learning in class. Thus, a needs assessment was conducted before the retooling projectfor the purpose of identifying topics that mathematics teachers perceived as difficult to teach. The trainees were identified by the Ministry of Education and Vocational Training (MoEVT) based on their working experience of fewer than five years, those who had not attended any in-service training and those with comparatively poor teaching performance. The analysis done before the training revealed that Mathematics teachers had difficulties in 19 content areas, namely function, irrational numbers, 3 dimension figures, teaching and learning aids, similarities, chord properties of a circle, probability, geometry, congruence, calculation of distances on the Earth's surface, location of places on the Earth's surface, operations on logarithm, displacement and position, vector, and probability of an event. Others are concept of a circle, compound angles, accounts, angle of elevation, and depression circles. Out of 473 tested O-level teachers in the 19 content areas, the descriptive statistics showed a mean score, m = 35.90 (sd = 16.60). Most of the teachers scored below the accepted mean score of 50. Most of them scored below 40, which is the pass mark for the candidates in NECTA.

Based on these observations, the retooling project was established by the then Ministry of Education and Vocational Training. This project focused on improving the quality of teaching and learning science and Mathematics in secondary education in Tanzania. The target was to use the latest ICT to design the contents that were perceived to be difficult in science and Mathematics in secondary education. For Mathematics, the project designed and digitized the content through various multimedia (videos, animations and voice-over) to facilitate the students' self-learning. According to Mtebe et al., (2015), the developed multimedia elements were integrated into content using Lectora software, uploaded into the Moodle Learning Management System (LMS) and produced in the form of DVDs to enable the students and teachers use them offline. These resources were provided to schools to enhance the teaching and learning of Mathematics.

The then MoEVT in collaboration with five institutions, namely the University of Dar es Salaam through the College of Information and Communication Technology (UDSM-CoICT), Mkwawa University College of Education (MUCE), Dar Es Salaam University College of Education (DUCE), State University of Zanzibar (SUZA), and the Open University of Tanzania (OUT) supervised the designing, developing and delivering of the content in schools. Each institution was supposed to guide the process in 500 secondary schools in the proximal locations. After six months, each institution, in collaboration with the subject matter experts (SMEs) from secondary schools and school quality assurance officials, had to conduct a monitoring and evaluation (M & E) study to find out the impact of the project. While the development process had some challenges, the majority of the users were satisfied with the quality of the developed multimedia-enhanced content (Mtebe et al., 2015).

Statement of the problem

According to Chokri (2012), when a new programme is introduced, it is important to determine the factors that influence people's behaviours and attitudes in the process of its adaptation. What was not known by the time of conducting this study was the extent to which the developed multimedia materials enhanced and upgraded pedagogical and subject content knowledge of the mathematics teachers while teaching in their respective schools. Monitoring and evaluation exercise aimed to find out whether or not the project had managed to upgrade subject content knowledge in Mathematics for secondary school teachers. The emphasis was put mainly on difficult topics in Mathematics.

Objectives of the study

Specifically, the monitoring and evaluation exercise aimed to assess the ability of mathematics teachers to handle the perceived difficult topics by students and examine whether the teachers had improved in terms of their pedagogical content knowledge during teaching.

The conceptual framework

Educators, especially in many developed and few developing countries have been using multimedia as a teaching tool for several years. It appears that multimedia can offer the experience of listening, looking and doing in a computer-mediated setting. The use of sound, photographs and video enables the user to experience authentic situations that may not be possible with conventional methods of instruction (Gebreyohanes, Bhatti & Hasan, 2016). This means that computer and multimedia technologies are simply the vehicle for teaching and learning, with the potential to overcome the limitations of traditional media in supporting the prospect to provide learning environments with strong visual elements (Ong et al., 2013).

For more than two decades, several studies have indicated the potential of digital technologies for mathematics education. In this regard, the National Council of Teachers of Mathematics in its position statement claims that "Technology is essential for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology" (National Council of Teachers of Mathematics [NCTM], 2008). Strategic use of technology strengthens mathematics teaching and learning (Dick & Hollebrands, 2011). The review by Hardman (2019) indicates that students' achievement in mathematics can be positively impacted using technology depending on the pedagogical practices used by the teachers. However, technology on its own appears to have no significant impact on students' attainment. Several studies regarding the impact of ICTs on mathematical attainment at primary school level also reveal positive contribution of technology to students' performance (Chauhan, 2017; Cheung & Slavin, 2013; Demir & Basol, 2014; Li & Ma, 2011; Tamim et al., 2011). Further findings from the reviewed meta-analyses indicate that students with special needs benefit more from technological input than neurotypical students (Higgins et al., 2012; Li & Ma 2011) and primary school students benefit more from ICT use than secondary school students. According to Baya'a and Daher (2013), ICT has a positive impact on students' learning, critical thinking and mathematics achievement. It is also widely acknowledged that ICT can be used to improve the quality of teaching and learning in the school system.

The integration of technology in Mathematics teaching and learning is not a panacea that reduces the importance of the teacher. Rather, the teacher has to facilitate learning by: synthesizing the results of technology-rich activities; bringing to light fruitful tools, techniques and; relating the experiences within the technological environment to paper-and-pencil skills or other mathematical activities. For the effective integration of technology in mathematics education, the pedagogical and technical expertise of the teacher is critical. Therefore, this study used *Reaction*, *Learning*, *Behaviour* and *Results (RLBR)* evaluation model proposed by Kirkpatrick and Kirkpatrick (2009) during monitoring and evaluation. According to Brewer (2009), during the evaluation of the programme*: reaction* focuses on how the participants react to the programme, *learning* focuses on the extent to which participants changed attitude, increased knowledge and/or skills. *Behaviour* focuses on the extent to which changes in behaviour occur*, and results* focus on the final results of the programme.

Study area

The M & E exercise was carried out in 36 districts from 17 regions (Table 1) whereby five regions with 10 districts from Zanzibar and 12 regions with 26 districts from Tanzania Mainland were involved in this study. The exercise targeted O-level secondary school teachers teaching Mathematics.

Table 1: *Regions and Districts Visited by the Participating Institutions*

S/N	Regions	Districts
1.	Iringa, Mbeya, Njombe	Iringa (U), Mufindi, Kilolo, Mbeya (U), Mbeya (R), Mbozi, Mbarali, Makambako
2.	Dar es Salaam, Mtwara, Morogoro	Kinondoni, Temeke, Mtwara-Mikindani, Masasi TC, Mvomero,

		Morogoro (R)
3.	Kigoma, Arusha, Geita, Dodoma, Manyara, Shinyanga	Kigoma (U), Kasulu, Arusha (U), Meru, Bukombe, Mbogwe, Dodoma (U), Babati, Mbulu, Shinyanga (U), Msalala, Ushetu
4.	North Pemba, South Pemba, North Unguja, South Unguja, Urban West Unguja	Wete, Micheweni, Wete-Mtambwe, Chakechake, Mkoani, Urban North B, Urban North A, Central, South, Urban.

Sample size

In the 17 regions that were visited in Tanzania Mainland and Zanzibar, a total of 148 teachers were assessed. Each implementing institution was required to conduct classroom observations and video recording for 125 randomly selected teachers out 500 teachers who were expected to be trained by each institution. However, due to geographical reasons and limited resources, it was not possible to visit all the teachers. Thus, the number of teachers was reduced to 40 per institution whereby 10 teachers per subject were randomly selected. The heads of schools where classroom observations were done were purposively selected as part of the sample.

Data collection methods

Various instruments and methods were used for data collection.

Table 2: *Data Collection Instruments and Methods*

S/N	Tool	Number of respondents	Method of data collection
1.	Classroom observation protocol	148	Video recording,
2.	Interview schedule for heads of	79	Interview, Video
3.	Interview schedule for students	64	Video recording,
4.	Interview schedule for non-	68	Interview, Video

Mathematics teachers were observed and assessed while teaching using the classroom observation protocol. The heads of the schools were interviewed to get their opinions about how their schools benefited from the retooling project. Furthermore, a sample of the students from each school, who were taught by the teachers who participated in the retooling training was subjected to interview.

Data analysis

Generally, all video-recorded events were analyzed to give qualitative information that was used to support classroom observations of a set of attributes prepared to inform on the ability of the teachers to demonstrate the acquired competencies through retooling programme. Classroom observation protocol consisted of a set of attributes that were organized into themes, including teachers' ability to teach the perceived difficult contents, formulating learning objectives, developing students' understanding, formative assessment, the influence of the classroom culture on students' learning, and the teachers' competence in the subject content. The attributes under each theme were presented in the observational tool in forms of a five-level rating scale. The first scale signifies very little ability, the second scale is little ability, the third scale is average, the fourth is high and the fifth is very high ability. The rated attributes under each theme were analyzed quantitatively using IBM-SPSS Statistics Version 21. The responses in each theme were combined and the mean of individual items determined to measure a latent variable and the reliability of the latent variable was also calculated using the Cronbach’s alpha reliability test. The responses from heads of schools’ unstructured interview were analysed and presented through quotations. The data collected from 76 interview groups of students were subjected to thematic analysis.

Results

The findings and observations of the study are presented in line with the competencies the teachers were expected to demonstrate after attending the training under the retooling programme. These competencies include the ability to teach difficult content reported during the needs assessment.

Teachers’ ability to teach perceived difficult content

The classroom observation protocol was used to assess the teachers' ability to teach the perceived difficult topics in Mathematics. The findings presented in this section focus on the teachers' ability to formulate the learning objectives; teachers’ ability to develop the students' understanding; teachers’ ability to make sense of the intended learning content; the influence of the classroom culture in students' learning; and teachers' competence on the subject content.

Formulating learning objectives: One of the aims of classroom observation was to examine the teachers' ability to formulate the learning objectives correctly, prepare lesson activities that directly addressed the stated learning objectives and propose the learning resources that were appropriate for realizing the set objectives. In this, three attributes were combined to form a scale with Cronbach's alpha reliability value of 0.7. It is important to note that the Cronbach's alpha reliability value greater than 0.3 shows that the data are acceptable for analysis. With regard to teachers' ability to correctly state the objectives that focus on the content, the observations showed that 27 out of 38 Mathematics teachers were able to state the objectives correctly. However, 11 teachers failed to state the objectives correctly. The stated objectives did not focus on specific action verbs that could guide the teachers to design active learning experiences.

The study also examined whether the teachers were able to prepare lesson activities that addressed the stated learning objectives. It was observed that 22(57.8%) out of 38 Mathematics teachers managed to set the learning activities that addressed the stated learning objectives. The study also revealed that 16(42.1%) out of 38 Mathematics teachers managed to propose the learning resources as per set objectives. However, nine teachers failed to propose relevant learning resources. For instance, one would expect the prepared lesson on dimensional figures to include learning resources such as three-dimensional models and real substances like boxes used to carry substances to represent cubes or rectangles, bottles of water or pieces of pipes to represent cylinders, constructed models of pyramids just to mention but a few. Instead, during classroom discussion, the teachers used to refer students to the drawn models in the books that do not represent the planes, angles and lines clearly in three dimensions.

Developing students' understanding: Another intention of the classroom observation was to find out the extent to which the teachers enabled students to construct their understanding based on concrete experience and evidence. In achieving this intention, the following attributes were examined: elicitation of prior understanding, cognitive/intellectual engagement, use of evidence, articulation of the lesson learned with real-life experience, formative assessment and relevance of activities. These attributes were combined to form a scale with the Cronbach's alpha reliability value of 0.8, a mean score of 3.1 and a standard deviation of 0.6.

The teachers demonstrated high ability in articulating the students' current understanding of the content. They also provided the learning tasks that engaged the students to think at a high cognitive level. The teachers managed to intellectually engage the students to think at a high cognitive level. On the other hand, the teachers partially engaged the students with the activities which were related to the lesson content, and others showed low ability to prepare the activities that engaged students to think at a high cognitive level. For instance, one of the prepared activities in three-dimensional figures demanded the students to explain the displayed figures, write the names of the figures, and various angles. One would expect the activities to include differentiation of the figures based on their critical features and create various three-dimensional figures based on the critical feature of the figures which are part of the higher-order thinking, and articulation of the lesson learned with real-life experiences.

Ability to conduct the formative assessment: This was another attribute that focused on the ability of the teacher to assess the students' understanding of the lesson. It was observed that 33 (86.8%) of Mathematics teachers were able to assess the lesson progress. However, 8.0% of the teachers showed a very low ability in assessing the lesson progress. The cross-tabulation was computed to find out the influence of the teachers' ability to develop the students' understanding. The observations showed that 8 (21.6%) out of 38 teachers performed better as almost all students had the opportunity to articulate their current understanding of the content and they recognized the range of pre-existing ideas held among their peers. The observations showed that 13 (34.2%) out of 38 Mathematics teachers had a very high capacity to engage the students in the activities related to cognitive/intellectual ability in using the designed content.

The study also observed the formative assessment which was conducted in the classroom. The aim was to evaluate the degree to which the assessment was done during classroom teaching and learning. It was found that 31(81.5%) out of 38 Mathematics teachers were either continuously or most of the time assessing the students' learning. Another area that the study evaluated was examining the relevance of the students' activities. It was further found that 35 (92.1%) out of 38 Mathematics teachers managed to plan the teaching and learning activities that were relevant to the students' understanding of the content.

Influence of the classroom culture on students' learning

Another attribute that was analyzed was the teachers' ability to motivate the students to understand the specific subject content during classroom discourse. It was observed that most of the teachers in Mathematics (81.1%, N = 38) reported motivating students to understand subject contents. The evidence was provided to the students during the focus group discussion that Mathematics teachers used a variety of learning experiences to guide them to learn at a slow pace. During the FGD, one student said, "Our Mathematics teacher brings models while teaching three-dimensional figures; It is motivating when she shows videos of three-dimensional figures that show clearly the angles beyond our eyes..." This argument was supported by other students who expressed being motivated in Mathematics learning by explaining that their interest in Mathematics increased because of the use of videos in teaching.

Teachers' competence in subject content

In this aspect, the focus was on the logical delivery and mastery of content, use of teaching and learning resources as well as the handling of students' questions. These attributes were combined to form a scale with the Cronbach's alpha reliability value of 0.7. The mean value of this category was 3.4 with a standard deviation of 0.6. As with the other categories, the data values ranged from 1 to 4 and their distribution was negatively skewed. These data indicate that the majority of teachers (82.4%) were competent in the subject content. This is a positive change taking into consideration that the development of retooling content was based on topics that were perceived to be difficult by many teachers. The contributions of the four attributes based on the teachers' competence were almost equal. The analysis of individual responses in each attribute showed that 97.4% (N = 38) of the Mathematics teachers delivered lessons effectively, sequentially and logically.

Further analysis of the performance showed that the majority of teachers (86.8%, N = 38) did not demonstrate misconceptions about lesson demonstration, thus indicating their excellence in the mastery of the subject contents. In the case of teachers' ability in using the teaching and learning resources, the findings show that Mathematics teachers who did not use any teaching and learning resources were 7 (18.4%) whereas 38 (52.6%) demonstrated the ability to use the teaching and learning resources. For instance, the observed lesson on three-dimensional geometry in the visited schools found a teacher teaching using real objects and constructed objects including boxes, pyramids, cubes, and rectangles. Also, the teacher had a PowerPoint presentation of similar objects. The presentation contained the objects and the narrations (both text and voice) describing the planes, angles, and lines in the objects. Seven teachers did not use either the teaching and learning resources or the courseware materials developed through the retooling project. The reason given by these teachers was the large class size and the rush to cover the large content in the subject. Majority of the teachers reported being able to respond to some or all students' questions appropriately.

The teacher gave an example of a question that was asked during teaching, "…why do the angles in the planes beyond our eyes seem to be larger than expected?" While such a question may seem difficult to answer under normal circumstances, through the use of the developed animations in the retooling materials, the teacher was able to answer it easily. The animation presented the outlooks of planes and angles of a three-dimensional object at different positions. However, 2 (5.9%) teachers could not respond to students' questions properly. Generally, the majority of Mathematics teachers (88.2%, N = 34) managed to respond well to students' questions.

Teachers' improvement in pedagogical content knowledge

A total of 76 students' group interviews were conducted to establish whether or not the teachers had improved in their pedagogical content knowledge after the training during classroom discourse. The size of students' groups for interviews ranged from six to forty students per class. The interviews focused on the students' attitude towards Mathematics as it was taught through ICT-enhanced pedagogy. On the students' attitude towards Mathematics, the findings indicated that most of them liked the subject for various reasons. The students claimed that they were motivated because the teachers used ICT which involved videos and animations more frequently than it was before in the teaching and learning process.

This implies that the trained teachers could apply technology to improve pedagogical content knowledge and eventually students' attitudes in Mathematics. Most students appreciated the use of technology in Mathematics that changed the teaching approach of their teachers. One student testified:

> Nowadays our teacher comes in class with lots of teaching materials including projector, videos, animations, pictures and many others…We understand the subject because the teacher uses diverse teaching strategies that help to understand the lessons more easily than before…I prefer more practical activities, the use of videos, demonstrations as well as real-life examples during the lesson. This makes me understand the lesson easily and interestingly…

When inquired to say what they dislike in the teaching approaches of their teachers, the majority of students replied that there was nothing they disliked. On the contrary, a few of them disliked punishments and being asked many questions by their teachers. The following comment was recorded from one student; "...I don't like many questions being asked by the teacher and the punishments that he gives in the class…."

Based on the students' views about their teachers, it clearly shows that the Retooling Project brought positive impact on teaching approaches used by Mathematics teachers who were trained in the project. Many students commended the teaching approaches used by their teachers. The majority of students [68 (89.5%) out of 76] agreed that their teachers used different teaching techniques including demonstrations, real-life examples, and ICT tools in teaching and learning. However, there were a few students from Kigoma, Mtwara, and Mbeya who revealed that their teachers could not use different teaching techniques, especially those involving ICT. Further research into this revealed that the challenge was compounded by lack of reliable electricity in the respective areas.

Challenges encountered in using retooling contents

More than half of the heads of schools (52.1%; N = 79) under study reported that lack of ICT facilities, particularly computers and liquid-crystal display (LCD) projectors was the most critical challenge. For instance, one head of school disclosed:

> My school has only one laptop and LCD projector. How can it be used for all Mathematics classes from form I to form IV?... this is a big challenge…I cannot blame teachers for not using the ICT materials provided to us…We need more laptops and projectors.

Other challenges mentioned include lack of electricity (15.7%), poor creativity of the trained teachers (9.9%), poor internet accessibility (5%) and unreliable electricity (1.0%).

Discussion

The retooling training used multimedia e-content and teaching and learning media which included computers and projectors which assisted the teachers in projecting the videos and animations for the difficult topics. It is widely acknowledged that the nature of the classroom culture is closely associated with the quality of students' learning. One attribute of the classroom culture was the classroom discourse that involves interactions between the teacher and students. A conducive classroom culture should create a democratic environment where students and teachers have an equal chance of generating knowledge through discourse. For instance, the use of appropriate and friendly teaching methodology and learning techniques influences positive classroom culture. According to Rennie and Edwards (2005), a classroom that uses technology provides students with a different learning experience. The designed ICT which enhanced digital materials in Mathematics was an attempt to assist the teacher to create conducive learning of difficult topics that appeared to hinder the students’ learning.

It has been shown in Chang and Yang (2010) and Gebreyohanes et al. (2016) that multimedia in education can create an environment that helps the students to learn using varied styles. In this way, the students are eager to participate in learning for understanding while the teacher is striving to assist them to learn through ICT-enhanced environment. This assists teachers to make effective preparations of appealing lessons, finding references and preparing resources (Charles-Ogan, 2015). This was the case in the retooling materials that enabled the teachers to change from teaching Mathematics for content coverage to teaching mastered specific content through ICT-enhanced methodology.

Therefore, creating positive change in the classroom culture from rote learning to learning for understanding brings a positive attitude among teachers and students. Chokri (2012) confirms that an indication of success in the implementation of the innovation is shown by the positive attitude that the practitioners show in the process of implementation that is, an indication of the success of the programme and vice versa is also true. This is the case whereby almost all heads of schools (98.7%) confirmed that the retooling training had improved the teaching performance of the teachers. However, this observation may be questionable as the study did not manage to conduct enough and detailed observations for classroom practices to establish the extent of the improvements the teachers demonstrated as a result of using retooling courseware materials. The teaching that focuses on the students' understanding is paramount in ensuring that the students can participate in the attainment of the national vision once they graduate.

As Tanzania strives to transform its economy to an industrialized economy, the teaching of Mathematics should focus on enhancing technological innovations. This thought is strengthened by Charles-Ogan (2015) who argued that the proper teaching of science, Mathematics, and technology can pave the way towards the transformation from a traditional economy to an innovative economy. This is possible if schools are equipped adequately with the necessary ICT facilities. The retooling materials involved the use of Digital Video Discs (DVD) that contained electronic content which requires electricity, computers, and projectors in the implementation. However, it was reported by the heads of schools and Mathematics teachers that the lack of ICT equipment and other Mathematics facilities were the main challenges encountered by the teachers in implementing what they learned from the retooling training. The availability of facilities and equipment is one thing and training the teachers on how to use them in the implementation of the developed innovations is yet another thing.

It is reported in McAleavy, Hall-Chen, Horrocks and Rigall (2018) that when teachers are supported to implement the technology-based materials or innovations, they do so through reflective and interpretive dialogue in the classroom. For this to occur, teacher orientation and training are imperative (Albert, Blanchard & Carrier, 2014).

The implementation of innovation in the classroom should borrow an appropriate conventional and appealing classroom culture. It was observed that during the implementation of retooling materials, many schools were lacking the teaching aids. The implementation also faced the English communication barrier and classroom congestion among some teachers and students. It should be recognized that the improvisation, especially in the classrooms in the developing countries, should go in line with the introduction of the innovations. For example, the use of alternative materials as teaching aids to bring the real world in the classroom is of paramount importance to complement the abstract phenomena that the technology cannot explain in any way. Since Mathematics is always perceived to be difficult by most students and teachers, monitoring and evaluation of any initiative should be done to promote the teaching and learning of the subject. It is argued that whenever students like Mathematics, they are likely to put more effort into learning it and in the long run they understand it.

Conclusion

The retooling training improved the teaching and learning performance of the trained teachers as evidenced by the improved pedagogical content knowledge technologies in schools. The retooling content had several videos and animations on the topics that were perceived as difficult to demonstrate through practice. For example, simulation of the Earth as a sphere was formerly impossible to demonstrate through practicals. Therefore, the pedagogical content knowledge and technical skills acquired by the teachers had a positive impact on assisting them to improve the teaching and learning of difficult content in Mathematics. This is to say that retooling content was designed in a self-instructional mode that enabled teachers to interact with the content easily. This implies that the retooling project can easily be scaled up to all teachers in the country.

Recommendations

The monitoring and evaluation (M & E) exercise recommends the following for successful implementation of the retooling project in the country:
The retooling training should be extended to all Mathematics teachers in the country. However, for a successful implementation of the project, the schools should be equipped with ICT facilities as well as improved electricity infrastructure and supply. This will enable the teachers to interact easily with the retooling e-content.

Individual schools should establish computer laboratories for ICT teaching and coordination. All schools should have a Mathematics resource room that is well-equipped for proper teaching and learning of the subject. Finally, there should be regular training and continuous M & E for Mathematics teachers to cope with fast-changing knowledge and technology.

References

Albert, J., Blanchard, M. R., Kier, M.W. & Carrier, S.J. (2014). Supporting teachers' technology integration: a descriptive analysis of social and teaching presence in technical support sessions. *Journal of Technology and Teacher Education, 22*(2), 137-165.

Baya'a, N.F. & Daher, W. M. (2013). Mathematics teachers' readiness to integrate ICT in the classroom: the case of elementary and middle school Arab teachers in Israel. *International Journal of Emerging Technologies in Learning, 8*(1), 46-52.

Bichi, A. A. (2018). Assessing students perception of difficult topics in Mathematics at senior secondary schools in Kano, Nigeria. *European Journal of Psychology and Educational Research, 1,* 53-59. 10.12973/ejper.1.2.53.

Brewer, E. W. (2009). *Assessing and evaluating adult learning in career and technical education*. China. Victor C. X wang, Ed. Zhejiang University Press.

Chang, C. & Yang, F. (2010). Exploring the cognitive loads of high-school students as they learn concepts in web-based environments. *Computers and Education, 55*, 673-680.

Charles-Ogan, G. (2015). Mathematics as a tool for achieving the vision 20:2020 goal of national transformation. *International Journal of Education, Learning and Development, 3*(8), 57-61.

Chauhan. S. (2017). A meta-analysis of the impact of technology on learning effectiveness in elementary schools. *Computer Education. 105,* 14–30.

Cheung, A.C.K., & Slavin, R.E. (2013). The effectiveness of educational technology applications for enhancing Mathematics achievement in K-12 classrooms: A meta-analysis. *Educational Research Review, 9,* 88–113.

Chokri, B. (2012). Factors influencing the adoption of the e-learning technology in the teaching and learning by students of a university class. *European Scientific Journal, 8*(28), 165-190.

Demir, S. & Basol, G. (2014). Effectiveness of computer-assisted mathematics education (CAME) over academic achievement: a meta-analysis study. *Educational Science Theories and Practice, 14*(5), 2026–2035.

Dick, T. P., & Hollebrands, K. F. (2011). Focus in high school Mathematics: tchnology to support reasoning and sense making. Reston, VA: NCTM.

Gebreyohannes , H, M., Bhatti, A. H. & Hasan, R. (2016). Impact of multimedia in Teaching mathematics. *International Journal of Mathematics Trends and Technology, 39*(1), 80-83.

Hardman, J. (2019). Towards a pedagogical model of teaching with ICTs for Mathematics attainment in primary school. *A review of studies*, 5(5), 2008–2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6538960/

Kirkpatrick, J. & Kirkpatrick, W. K. (2009). *The Kirkpatrick Four Levels: a fresh look after 50 years 1959-2009*. Kirkpatrick Partners, LLC.

Li, Q. & Ma, X. (2011). A meta-analysis of the effects of computer technology on school students' Mathematics learning. Educ. *Psychology. Review*, *22,* 215–243.

McAleavy, T., Hall-Chen, A., Horrocks, S. & Riggall, A. (2018). *Technology-supported professional development for teachers:*

lessons from developing countries. London: Education Development Trust.

Mtebe, S., Kibga, E.Y., Mwambela, A. A, & Kissaka, M. M. (2015). Developing multimedia enhanced content to upgrade subject content knowledge of secondary school teachers in Tanzania. *Journal of Learning for Development, 3*(2), 29-44.

Ong, B. H., Abd Halim, N. D., Shariffuddin, S., & Abdullah, Z. (2013). Computer-based courseware in learning mathematics: potentials and constraints. *Procedia--Social and Behavioural Sciences, 103,* 238-244.

Ozdamli, F., Karabey, D., & Nizamoglu, B. (2013). The effect of technology-supported collaborative learning settings on the behaviour of students towards mathematics learning. *Procedia - Social and Behavioral Sciences, 83,* 1063-1067.

Pardimin, P. & Huda, M. (2018). Investigating factors influencing mathematics teaching performance: an empirical study. *International Journal of Instruction, 11*. DOI:10.12973/iji.2018.11327a.

Persico, D. & Pozzi, F. (2011). Task, team and time to structure online collaboration in learning environments. *World Journal on Educational Technology, 1*(3), 1-15.

Rameli, M. R. M. & Kosnin, A. M. (2016). *Challenges in Mathematics Learning: A Study from the School Student's Perspective.*

Rennie, R. & Edwards, K. (2005). *The science classroom of tomorrow: analyzing exemplary science teaching: theoretical lenses and a spectrum of possibilities for practice*. S. Alsop, L. Bencze, and E. Pedretti, Ed. England: Open University Press, 32-37.

Saleh, R. & Alias, N. A. (2012). Learner needs analysis for mobile learning comic applications among dyslexic children. *International Journal of Education and Information Technologies, 6*(2), 185-192.

Samwel, K., Mulenga, D. M., &Angel, M. (2016). An investigation into challenges faced by secondary school teachers and pupils in algebraic linear equations: a case of Mufulira District, Zambia. *Journal of Education and Practice*, *26*(7), 99-106.

Taleb, Z., Ahmadi, A., & Musavi, M. (2015). The effect of m-learning on Mathematics learning. *Procedia-Social and Behavioural Sciences, 171,* 83 –89.

Tamim, R.M., Bernard, R.M., Borokhovski, E., Abrami, P.C. & Schmid, R.F. (2011). What forty years of research says about the impact of technology on learning: a second-order meta-analysis and validation study. *Review of Educational Research. 81*(1), 4–28.