Using SMS Mobile Technology to Assess the Mastery of Subject Content Knowledge of Science and Mathematics Teachers of Secondary Schools in Tanzania

Joel S. Mtebe, Aron Kondoro, Mussa M. Kissaka, Elia Kibga

Abstract—Sub-Saharan Africa is described as the second fastest growing in mobile phone penetration in the world more than in the United States or the European Union. Mobile phones have been used to provide a lot of opportunities to improve people's lives in the region such as in banking, marketing, entertainment, and paying for various bills such as water, TV, and electricity. However, the potential of mobile phones to enhance teaching and learning has not been explored. This study presents an experience of developing and delivering SMS based quiz questions used to assess mastery of subject content knowledge of science and mathematics secondary school teachers in Tanzania. The SMS quizzes were used as a follow up support mechanism to 500 teachers who participated in a project to upgrade subject content knowledge of teachers in science and mathematics subjects in Tanzania. Quizzes of 10-15 questions were sent to teachers each week for 8 weeks and the results were analyzed using SPSS. Results show that teachers who participated in chemistry and biology subjects have better performance compared to those who participated in mathematics and physics subjects. Teachers reported some challenges that led to poor performance, This research has several practical implications for those who are implementing or planning to use mobile phones in teaching and learning especially in rural secondary schools in sub-Saharan Africa.

Keywords—Mobile learning, e-learning, educational technologies, SMS, secondary education, assessment.

I. INTRODUCTION

THE growing adoption and penetration of mobile phones along with other data capable devices such as tablets and dongles have been increasing very fast in sub-Saharan Africa. There are almost 650 million mobile subscriptions in Africa, equivalent to a penetration rate of 68%, more than in the United States or the European Union making Africa the second fastest growing region in the world in mobile phone penetration [1]. The GSMA report projected that, the 3G connections is expected to increase from 15% of total in 2013 to 52% by 2020 while smartphones will increase from 72 million to 525 million by 2020.

In Tanzania, there are 31milions mobile phone subscribers accounting to 69% of total population [2]. The country was ranked 4th by International Telecommunication Union (ITU) for mobile phone penetration in Africa in 2010 after Nigeria, South Africa, and Kenya [3]. At the same time, the prices of mobile phones have been plummeting to as low as 30 US$ in many parts of the country.

Mobile phones have been providing a lot of opportunities to improve people lives in sub-Saharan Africa. They provide users with access to education, health information, and payments services even in place without banks. Moreover, the mobile phones and applications help Africans to overcome traditional market failures such as communicable diseases, and clean water and sanitation as well as government failures such as absentee teachers and doctors, patronage-ridden water and electric utilities, etc.

Users in Africa tend to various mobile phones features to obtain these services. These features include phone calls and Short Message Service (SMS). In addition, due to lack of affordability, coverage and reliability of fixed networks in Africa, people normally use mobile phones to access the Internet [4]. According to Ericsson report of 2013, 70% of users in Africa browse the web on mobile devices, compared to just 6% who use desktop computers [5]. Nonetheless, SMS is the most common and most used mobile service, as it is available in every mobile phone. The SMS service also uses little memory and easy to use as users do not need training to be able to use it [6]. In light of these advantages, the number of SMS traffic has been increasing very fast in Africa. For instance, the number of SMS increased from 608 millions in June 2011 to 7.9 billions in March 2015 in Tanzania [7]. In other words, on average a Tanzania user sent 36 text messages in June 2011 with the number of text messages increasing to 349 per user in March 2015 [2], [8].

Naturally, SMS service is the most used service in sub-Saharan Africa, such as in banking, marketing, entertainment, and paying for various bills such as water, TV, and electricity. However, the potential of using SMS to enhance teaching and learning specifically as a tool for conducting formative assessment has not been explored in Africa [9]. Therefore, the Ministry of Education and Vocation Training (MOEVT) in collaboration with the College of Information and

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Communication Technologies (CoICT) of the University of Dar es Salaam adopted SMS quizzes as a follow up support mechanism to teachers who participated in a project to upgrade subject content knowledge of Tanzanian secondary school teachers in science and mathematics.

In this project, multimedia enhanced content for difficulty topics in chemistry, biology, physics, and mathematics was developed and packed into Digital Video Disc (DVDs). A total of 2,000 teachers in 19 selected centers countrywide were trained on how to use the content and given the DVDs to continue accessing the learning materials at home. Teachers were also given access to the same content which was made available online through a customized Moodle system accessible via http://retooling.udsm.ac.tz.

In order to assess if teachers have improved their subject content knowledge, a follow up SMS based assessment tool was developed and used to send quiz questions to a sample of 500 teachers for 8 weeks. The SMS quizzes were carefully chosen and designed to provide formative evaluation during the subjects' delivery given the limitations of the SMS technology. This article presents an experience of study conducted to develop and deliver SMS quiz questions. More specifically, the article aims at:

- Sharing experience obtained during the development and delivery of SMS quizzes to teachers in secondary education in Tanzania
- Presenting the performance of teachers in SMS quizzes
- Presenting opinions of teachers towards using SMS quizzes for conducting assessment in secondary schools.

II. RELATED WORKS

SMS service is the most widely used mobile phone service in developing countries. However, using SMS for teaching and learning is not very common in Africa due to some limitations. One of the major limitations is that it uses short texts ranging between 160 to 150 characters on some older phones [6], [9]. As a result, for assessment for instance, quiz questions are limited to true/false, multiple choice selection and short answers questions [10]. Despite these limitations, SMS service has been used for academic administration.

Jones, Edwards, and Reid [11] developed an SMS system to provide communication between students and tutors. The SMS communication was used in concert and integrated with lectures in a virtual learning environment. Naismith [12] reported the use of SMS on administrative staff to communicate on room changes, submission deadlines, cancellations, etc. These studies and many others have indicated that the use of SMS for administrative have positive impact on students' dropout rate and helped to support 'at risk' students [13].

In addition to administrative support, some studies have used SMS for conducting formative assessment. For instance, [14] developed the SMS system that provided formative assessment questions with feedback. The formative assessment included quiz questions that consisted of multiple choice and True/False questions. Similarly, [9] designed SMS based system to deliver quizzes as an alternative for formative

assessment of teaching and learning for courses at institutions of higher learning in Malaysia. The study showed that students who tried the quizzes for a few times were excited with the ability of the system to supply the quiz questions and answers instantly via SMS.

Although many studies to use SMS as a tool for supporting teaching and learning have been reported from developed countries, some initiatives have started to emerge in sub-Saharan Africa. The recent study was conducted by [15] to implement a dynamic Frequently Asked Questions (FAQ) system. The system incorporated SMS where anonymity was key to enable a more inclusive learning environment [15]. The system was piloted with students at the University of Cape Town. Overall, the study highlighted the potential for SMS to support learning in higher education.

To date, there are few studies that have used SMS as a tool for supporting assessment in secondary education in sub-Saharan Africa. This study is one of the few studies that have used SMS to conduct formative assessment via quizzes to 500 teachers in secondary schools in Tanzania.

III. DEVELOPMENT AND DELIVERY OF SMS QUIZ QUESTIONS

A. SMS Quiz Questions

The SMS questions were developed by subject matter experts based on the learning content provided to teachers through DVDs. A total of 34 set of quizzes were developed, 12 of them being for physics, 12 for chemistry, 10 for biology and 8 for biology. Each quiz had between 10 and 12 questions depending on the breadth of the topic. The questions were in two forms: the multiple choice and True/False. Examples of multiple choice questions are:

1. Member of Phylum Platyhelminthes
A. Liverflukes,
B. Hookworms
C. Roundworms
D. Earthworms
2. Turbellarians are
A. Commensal and non-parasites
B. Ecto- and Endo- parasites
C. Free living and parasites
D. Ecto parasites and freeliving
3. Proglotids are features of
A. Trematoda
B. Tuberallia
C. Nematoda
D. Cestoda

Teachers were required to answer each question at a time by sending a message with a letter for the correct answer only. Examples of True/False quiz questions are:

- *The instrument most suitable for measuring diameter the wire is Vernier Callipers (Write T for true and F for false)*
- *Micrometer screw gauge is used to measure diameter of a small ball (Write T for true and F for false)*
- *Probe of the Vernier calliper can be used to measure the depth of a small amount of water in a beaker? (Write T for true and F for false)*

- *The function of the Cathode Ray Oscilloscope (CRO) screen is to display the output signal (Write T for true and F for false)*

B. Selection of Teachers

A total of 2,000 teachers were randomized to get 500 teachers (125 teachers for each subject) who were eligible to receive SMS quizzes. Before starting sending quiz questions, the system was tested for a period of one week by sending messages to eligible teachers who were required to respond with a single SMS, in order to confirm their reachability, and be eligible to receive vouchers for the first week. The system also provided instructions on how to respond correctly to quiz questions. Similarly, at the end of the fourth week before continuing with the fifth week, the same exercise was conducted again to capture those who could not be reached from week one.

It was important to check if the eligible teachers were reachable before sending quiz question as some teachers could have changed their telephone numbers or the numbers were not reachable for some reasons. A total of 486 teachers (physics = 113, biology = 122, chemistry = 123 and mathematics = 128) were reachable. One quiz consisted of 10-15 questions for each subject was sent to teachers on each week for 8 weeks. The questions were sent based on the modules teachers were supposed to study on a particular week.

To enable teachers to respond to quiz questions, teachers were provided with voucher worth Tshs 2,000 (about US$ 1) every week. Those who managed to answer all questions at a particular week were eligible to get another voucher for the following week. However, those who could not finish all weekly questions were not given vouchers for that week until they answer all questions of the next quiz.

III. THE SMS PLATFORM

The project adopted the Telerivet platform that supports sending and receiving SMS as well as multimedia messages. The platform is android based that can be installed on any smartphone with Android 2.1 or higher.

When an SMS is received on the smartphone's number, it is forwarded to the platform through the data connection. Similarly, when a message is sent from the platform to the recipient's number, it passes through the same connection to the smartphone. This allows any normal android smartphone to be used as an inexpensive mechanism to send and receive messages to a large number of participants. In addition, since Telerivet is a cloud-based management system, the project did not procure computer servers to send SMS quizzes to teachers. The ability to use normal phones with long numbers, also allowed the project to avoid the cost of buying special short code numbers.

Due to the large number of participating teachers, four android phones (Samsung Galaxy Note 4) were bought in order to act as SMS gateway. To route messages at all times, the phones were turned on, charged, and connected to the Internet all the time. During testing phase, one mobile phone was used as a gateway. As the number of SMS continued to increase, a significant delay was noted in routing messages to teachers. Due to technical limitations and mobile operator policy, a single mobile phone can only send a limited number of messages per hour. Therefore, it was necessary to use multiple phones to handle the large number of messages (more than 1800 SMS messages per quiz per subject) per week.

All quiz questions were uploaded into the platform before the sending phase of the project started. Telerivet is organized into what are known as 'services', where a single service can be a survey, quiz, or questionnaire that is sent to participants via SMS. Only one service can be active at a time. Every quiz was setup as a separate service and then activated one by one each week as the project progressed. Once a quiz was activated, the first question was sent via the smartphone application and arrived as an SMS on a teacher's phone. Fig. 1 shows a sample quiz question from teacher's mobile phone screen.
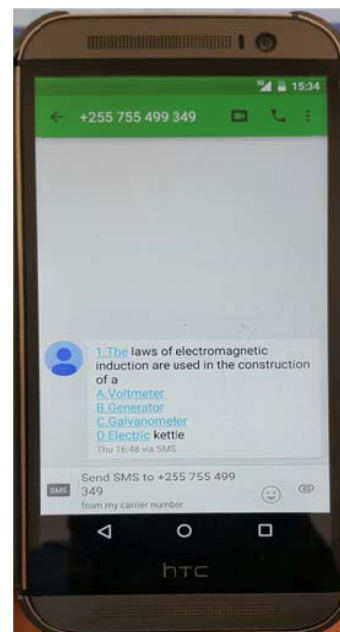

Fig. 1 Sample quiz question from teacher's phone screen

When a teacher replied, the answer was sent back again to the platform via the mobile application. Thereafter, the answer was recorded and automatically marked according to the preconfigured correct answer. The next question in that week's quiz was then sent to the teacher. Once all questions were sent and replied to, a final message containing the results of that particular week questions was sent to the teacher. For every question that a teacher got wrong, the correct answer was also indicated.

For analysis purposes, basic teachers' information such as their names, phone numbers, teaching subjects, institution, location (region), and phone type was stored on the platform. This information was collected during the training phase, and was then manually entered into the platform through Telerivet's web front-end. Fig. 2 shows a sample of this data.

The performance of every teacher was recorded on a weekly basis, and then exported into csv format for further analysis.

Fig. 2 Sample of Teachers' data from Telerivet web front end

IV. FINDINGS

For the duration of 8 weeks, quiz questions were sent to a total of 486 teachers every week. At the end of every week, the responses were recorded and analyzed. The SMS responses were categorized as different important categories as described in the next section.

A. Non-Responses

Every week there were a number of teachers who did not respond to any quiz questions. Fig. 3 shows the number of teachers who did not respond to any quiz question in each subject for the period of 8 week.

The result from Fig. 3 shows that mathematics teachers consistently had the highest number of non-respondents compared to the other subjects. Out of 8 weeks, the first week had the lowest number of non-respondents, followed by the third, fifth and sixth week. Interestingly, the first and fifth weeks were the ones preceded by a week in which teachers were sent instructions on how to respond to quiz question and reminded to re-confirm their participation.

B. Invalid Answers

Some of the received answers were categorized as invalid. If the answer to a particular question was "A", the correct accepted answer would have been "A" or "a". Any addition, omission or alteration would be considered invalid answers. For instance, instead of answering "A" or "a" teachers sent "1. A", or "The answer is A "or "Ans = A" would all be considered invalid answers.
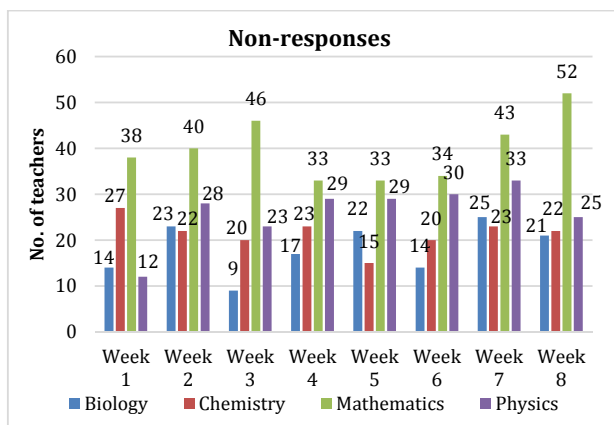

Fig. 3 Number of non-respondents in each subject for the 8 weeks

The result shows that they were many invalid answers in the first two weeks and continued to decrease as weeks progressed as shown in Fig. 4. It seems that at the beginning the instructions were not clear enough to teachers. In addition, biology and chemistry had the highest number of invalid answers compared to other subjects.

C. Teachers Who Did Not Complete All Questions

There were teachers who answered only few questions of a given quiz for a particular week. The number of teachers who did not finish all quiz questions increased as weeks progressed with mathematics teachers having the highest number throughout the period as shown in Fig. 5. Interesting,

chemistry had the lowest number of teachers who did not finish all quiz questions throughout the period.
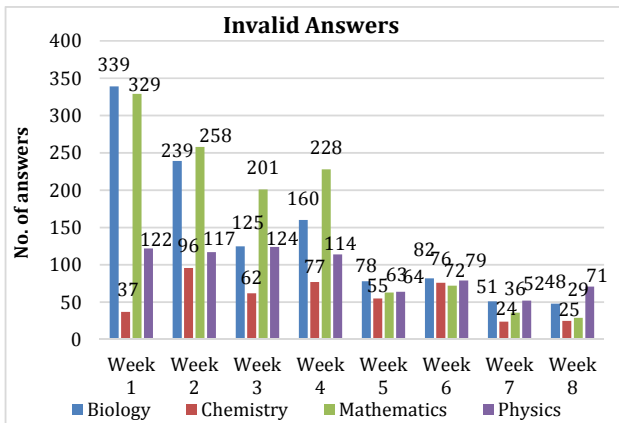

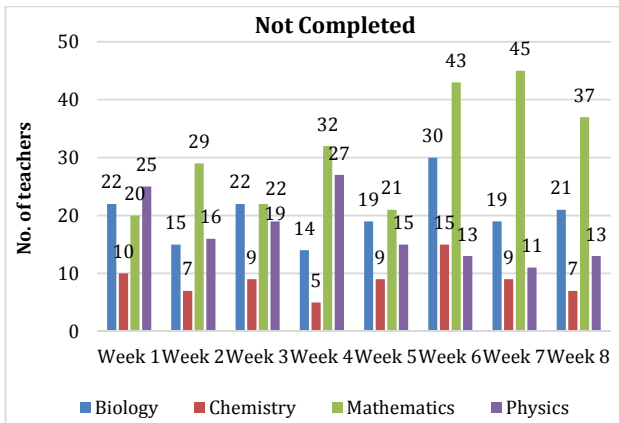Fig. 4 The number of invalid answers

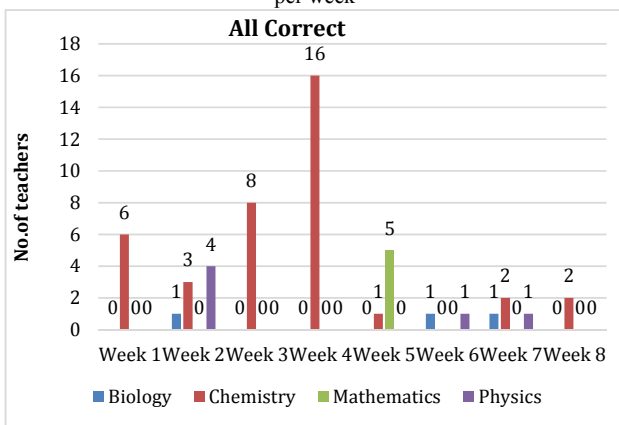Fig. 5 Number of teachers who did not complete all quizzes questions per week

Fig. 6 Number of teachers who got all questions correct per week

D. Teachers Who Got All Answers Correct

In each week, there were a few teachers who managed to answer all the questions correctly. As it can be seen in Fig. 6, chemistry was the subject that consistently led in this category. In particular, chemistry was the only subject that had

at least one teacher who got a perfect score in every week. Interestingly, no mathematics teacher managed to get all questions correctly except in the fifth week, in which 5 teachers answered all questions correctly.

The general trend observed was that more teachers were getting a perfect score for the first four weeks compared to the later ones.

E. Teachers Who Got Less Than 50% Answers Correct

We were also interested to know the number of teachers who got less that 50% of quiz questions correct for each week in 8 weeks period. Through data analysis, it was revealed that less than half of the teachers got less than 50% of the questions correct every week. In the first three weeks, biology had a high number of low performing teachers, but as time went on mathematics became the subject with consistently highest number of low performers.

Chemistry had always a small number of teachers who answered less than 50% answers correctly in exception of week seven. Fig. 7 shows the number of teachers who managed to get less than 50% answers correct.
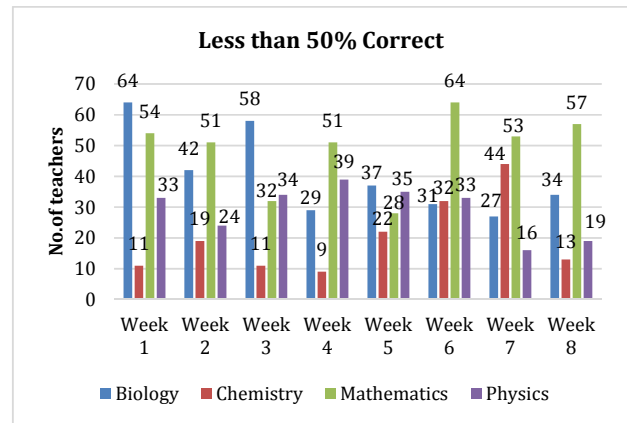

Fig. 7 Number of teachers who managed to get less than 50% answers correct

F. Teachers Who Managed to Get More Than 50% of Answers Correct

The results indicate that chemistry teachers had the highest performance in all weeks followed by biology teachers. As expected, mathematics had the lowest performance of all subjects (Fig. 8).
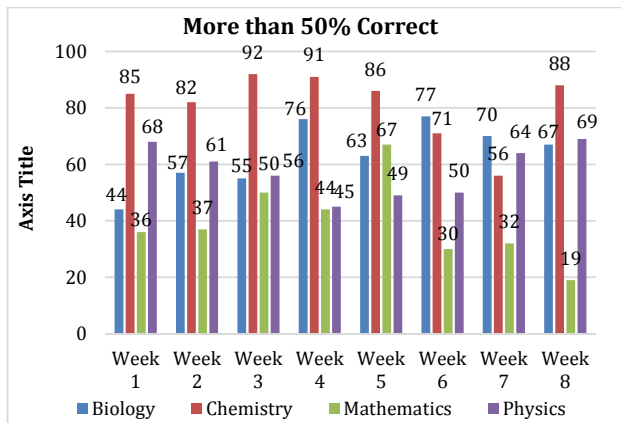
Fig. 8 Number of teachers who managed to get more than 50% of answers correct

V. OPINIONS OF TEACHERS TOWARDS USING SMS QUIZZES IN CONDUCTING ASSESSMENT

After 8 weeks of answering quiz questions, we were interested elicited teachers opinion about how they perceived the SMS quiz assessment as a tool for conducting formative assessment. The questionnaire comprised of 12 questions was prepared in SMS based platform and sent to 486 teachers who were involved in SMS quiz questions. Respondents were asked to rate each question using a 5-point Likert scale that ranged from strongly disagree to strongly agree with the exception of last two questions. They were given 3 days to respond to the data collection tool.

Out of 486 teachers who received questions through SMS, 266 teachers responded. Thus, the response rate was 55%. Data was extracted from Telerivet system and exported into Statistical Package for the Social Sciences (SPSS) for analysis. The findings from each question are presented hereunder.

A. Instructions and Nature of the Questions

Given the large number of invalid answers in the first two weeks, we were interested to know if the instructions that were provided to teachers on how to answer quiz questions were clear or not. Surprisingly, the minority of respondents (10%) indicted that the instructions were not clear and confusing with more than two-thirds of respondents (88%) indicted that the instructions were clear.

We were also interested to know the nature of the quiz questions themselves if they were clear or not. The results show that the majority of the teachers (89%) agreed that the quiz questions were clear with very few teachers (9%) indicted that the questions were not clear and confusing. Fig. 9 shows respondents' comments on quiz instructions and quizzes questions.

B. Difficultness of the Quiz Questions

We were also interested in comparing the performance of teachers with their opinion regarding the difficultness of the subjects. Therefore, we were interested to get teachers opinions on the quiz questions as difficulty or not. The results show that many teachers indicated that the quiz questions were

moderate (71%), while the minority (7%) indicted the questions were difficulty. However, 22% of respondents indicated that the quiz questions were easy as shown in Fig. 10.
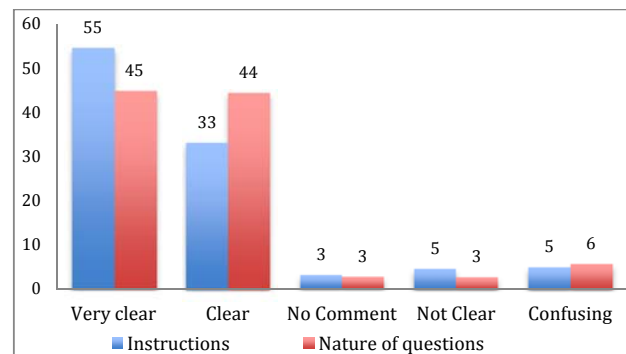

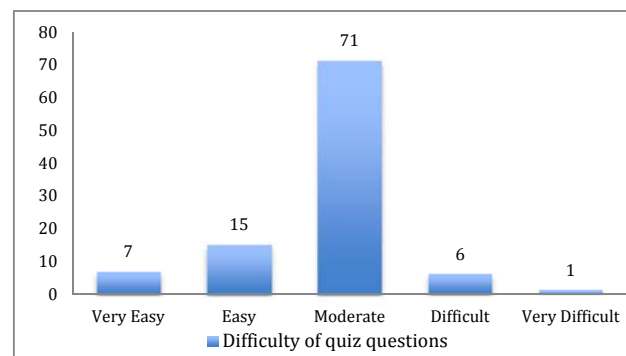Fig. 9 Respondents comments on quiz instructions and quizzes questions

Fig. 10 Teachers opinions' regarding difficulty of quiz questions
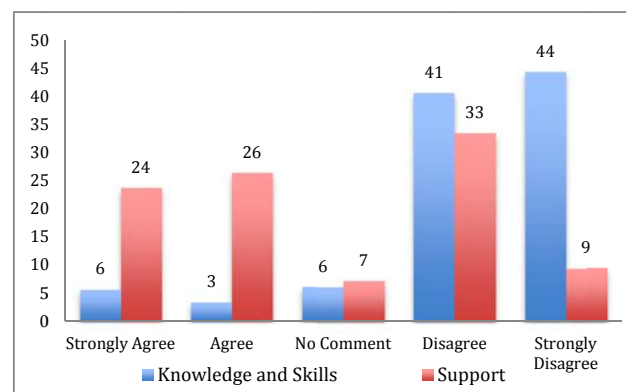
Fig. 11 Teachers' opinions on knowledge and skills improvement, and support

C. Improving Teachers' Knowledge and Skills

Respondents were also asked to provide their opinion on whether the quizzes have helped them in improving their knowledge and skills to teach their subjects more effectively. As shown in Fig. 11, the majority of teachers (85%) indicated that SMS quiz exercise did not help them to improve their knowledge and skills to teach their subjects. In addition, we

were also interested to know if teachers received required support from CoICT and other people when they had problems in answering quiz questions. Half of respondents (50%) indicated that they were helped when they had problems while 42% of respondents indicated that they did not get help from CoICT or elsewhere when they had problems in answering quiz questions.

D. Using Mobile Phones for Assessment

Since teachers used mobile phones as a tool to answer quiz questions, they were asked their perceptions and opinion on using mobile phones for the same. First, they were asked to indicate whether using mobile phones to answer quiz questions was easy, clear, and understandable. Second, they were asked whether using mobile phones to answer quiz questions was fun, enjoyable, and entertaining. Finally, they were asked to rate if using mobile phones for answering quiz questions was convenient.

Generally, the majority of respondents (85% of respondents) disagreed that using mobile phones to answer quiz questions was easy, clear, and understandable. Similarly, more than 77% of respondents disagreed that using mobile phones for answering quiz questions was fun and enjoyable. Moreover, 79% of respondents indicated that using mobile phones for answer quiz questions was not convenient. Fig. 12 shows the distribution of respondents based on their perceptions on using mobile phones for answering quiz questions.
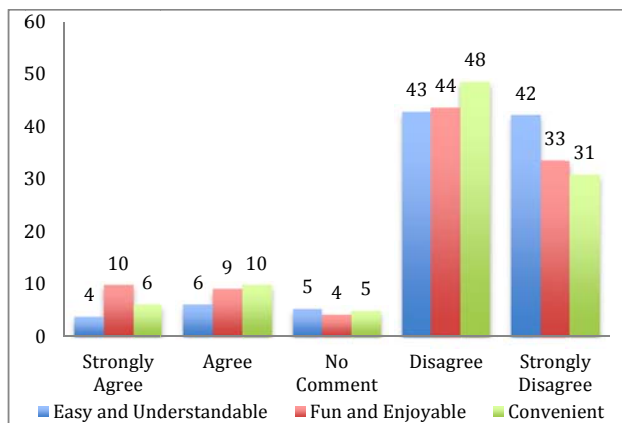

Fig. 12 Respondents' perceptions on using mobile phones for answering quiz questions

E. Using Mobile Phones in Tanzania Secondary Schools

We wanted to know teachers' opinions on the use of mobile phones to facilitate students' learning as well as if they can be used to facilitate examinations in secondary schools in Tanzania. Respondents were almost equally divided on their opinions on whether mobile phones can be used to facilitate examinations with 44% agreed while 48% of respondents disagreed. However, more than two-thirds of respondents (73%) disagreed that mobile phones can be used to facilitate students' learning in secondary schools as shown in Fig. 13.
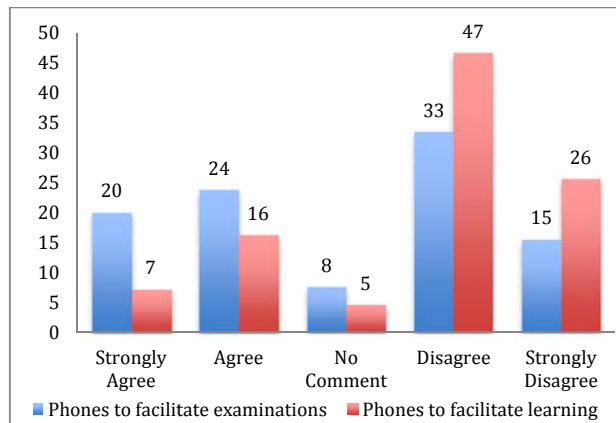

Fig. 13 Teachers opinions on the use of mobile phones to facilitate students' learning and examinations

F. Challenges Faced During Answering Quiz Questions

Finally, teachers were asked to explain the challenges they encountered during answering quiz questions. The majority of those who responded to this question indicated that unreliability of network was then main challenge that hindered them from answering quiz questions. There was a time delay in delivering one question to another in a given quiz. For instance, some teachers commented:

"Sometimes the difference between the first question and another takes a long time"

"The time between one SMS and others took long time"

"Sometimes SMS took long time to be delivered, then after sometime, all SMS come together then it became even difficult to answer them"

Due to such delays sometimes questions were received incomplete or in unsystematic order therefore becoming difficult for teachers to answer. This is evident from the comments from teachers below:

"Some SMS were overlapping due to network problems that caused me to answer wrong for a particular question"

"During early weeks many questions were received in an improper order and they were incomplete"

"Incomplete questions and receiving a quiz in parts, and sometimes the questions were received during night hours"

Another biggest challenge described by many teachers is the time when the quiz questions were delivered. It seems due to network problems or other problems some quiz questions were received overnight and thus it was difficulty for them to answer. Moreover, in some cases quiz questions were received when teachers were busy with daily activities such as teaching activities. This is evident from the following comments:

"The main challenge was the time because I always receive questions when I was very busy with other activities"

"The SMS were sent during working times, so it was hard to answer them on time"

"Some questions require tools like calculator and I received them when I did not have such tools as I was in the bus travelling"

V. DISCUSSION

The study was set to present an experience of developing and delivering SMS quiz questions to assess mastery of subject content knowledge of science and mathematics secondary school teachers in Tanzania. The SMS quizzes were adopted as formative assessment aiming at informing the teachers about the progress of their learning as well as to provide the decision makers with opportunities to address and improve the plausible shortages in order to ensure that teachers do upgrade their subject content knowledge.

One interesting trend observed from this study was that teachers could not understand well the instructions that were provided on how to answer quiz questions. For instance, teachers were told to write only a letter (e.g. "A") for the correct answer, however, some teachers added other characters such as "Ans=A" or "A." and so on. As a result, the number of invalid answers was large in the first two weeks and kept on decreasing as the week progressed. This shows with time, teachers could understand the instructions on how to respond to quiz questions. This is also evident from the comments received from teachers when they were asked if they found instructions provided before answering quiz questions clear or not. The result shows that the majority of teachers indicated that the instructions were clear and understandable. The study also found that the number of non-responses increased as weeks progressed. For instance, there were 38 teachers who did not respond to quiz questions in the first week for mathematics and increased to 46 in the third week and 52 in eighth week. The trend is almost similar in all subjects. A possible explanation for this might be that those did score zero in all questions in the first weeks were discouraged to continue answering subsequent quizzes. That is why mathematics and physics that had many teachers who scored less than 50% had the highest non-responses throughout the eight weeks.

In general, the main conclusion that can be drawn from these results is that chemistry and biology teachers were able to upgrade their subject content knowledge of the subjects they teach more than those of physics and mathematics. However, these results therefore need to be interpreted with caution, as SMS quizzes alone do not automatically guarantee improvements in the teachers' learning. Sadler pointed out that in order to increase the possibility that the formative assessment such as those of SMS quizzes to have the expected value, teachers have to possess skills so that they are able to translate what they have learnt into actual teaching environment [16]. It was also interesting to note that the majority of teachers (85%) did not agree that SMS quiz questions helped them to acquire new skills and knowledge to be able to teach the subjects more effectively. The result was somewhat surprising given the fact that many teachers (71%) found quiz questions were moderated. A possible explanation for this might be that since teachers have not applied what they have learnt in the classroom, they are not in a position to think that they have improved their skills and knowledge to teach well their subjects.

One unanticipated finding obtained from this study was that many teachers indicated that using mobile phones to answer quiz questions was not easy, fun and enjoyable, and convenient. This result could have been caused by the challenges teachers faced during answering quiz questions. Many teachers complained about the network problems. The network problems caused teachers to receive incomplete quiz questions and therefore they could not answer them properly ending up getting incorrect answers. In addition to that, some teachers indicated that time between one SMS to another SMS was too long that sometimes they ended up receiving quiz questions beyond midnight and therefore it was not possible for them to respond. Due to these challenges and many others, it was not surprising that the majority of teachers (73%) felt that mobile phones cannot be used to facilitate students' learning in secondary schools in Tanzania. However, almost half of teachers (44%) indicated that the mobile phones could be used for conducting assessment in secondary schools.

Based on teachers' comments, it is clear that the success of mobile learning depends on the availability and reliability of mobile technology. In this study, some invalid answers, or incorrect answers were a result of network connectivity problems. The similar studies or future research should ensure that the technology used to send and receive SMS have the capacity to handle massive messages without delays. Despite these limitations and challenges, this research has several practical implications for those who are implementing or planning to use mobile phones for teaching and learning especially in rural secondary schools in sub-Saharan Africa.

VI. RECOMMENDATIONS FOR FUTURE RESEARCH

The present study has successfully showed that mobile phones can be used to support teaching and learning in Africa especially in rural secondary schools. Through this study, it is clear that many teachers have access to mobile phones of various kinds. However, the cost of data is still very high and many teachers could not afford to send SMS or use mobile phones to access learning content via the Internet. According to Brown and Mbati, the cost of data in Africa is 150 times the cost of a comparable service in developed countries [17]. To address this problem, the project provided vouchers worth 1 US$ for each teacher per week in order to help them to answer quiz questions. Although the approach seemed to be successfully, it is not sustainable after the end of the project. Similar projects in the future studies could request mobile phone companies to reduce the cost of data in order to enable many teachers to use their mobile phones for teaching and learning. Another important challenge we faced during the development of quiz questions was how to send symbols, formulas, and diagrams as SMS especially for chemistry and mathematics subjects. To overcome this challenge, we had to use abbreviations that represent some symbols and formulas. For instance, square root as "sqrt" and other related abbreviations. This could have contributed to increased number of failures in these subjects, as some could have failed

to interpret these abbreviations correctly. Future studies should plan to use mobile apps instead of SMS to send quiz questions to respondents. However, it should also be noted that many teachers especially in rural areas do not have smartphones and cannot afford Internet cost to be able to use mobile apps.

VII. CONCLUSION

The price of mobile phones is decreasing very fast as well as the price of data in the region. Smartphones are also becoming cheaper and affordable to the majority of users in Africa. Moreover, mobile phones have been widely used in various services such to provide access to banking services, heath services and payment services.

At the moment, there are very few initiatives to use mobile phones to widen access and to improve quality of education. This study used mobile phones specifically SMS service to provide formative assessment to teachers who were using multimedia enhanced content in order to assess if teachers improved their subject content knowledge.

Although some challenges were reported during the development and delivery of SMS based quizzes to teachers, the main conclusion that can be drawn from this study is that mobile phones can be used as tools to enhance teaching and learning in rural secondary schools in sub-Saharan Africa. Future research should consider how to address some of the challenges reported in this study in order to implement similar project more successfully.

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