Experimenting on the Added Value of M-Learning for the Teaching of Word Problems

K. M. Cassim, S. D. Eyono Obono

***Abstract.* —The aim of this paper is to examine the use of Mobile Learning (M-learning) for the teaching of word problems. This aim is achieved by qualitatively analyzing interviews data from three second grade teachers from urban and rural schools from the Kwa-Zulu Natal Province of South Africa. These teachers were interviewed after the participation of their learners in an experiment in which M-learning was used for word problems homework. Results from this experiment indicate that M-learning improves learners' performance, attitudes and excitement with regard to word problems. All the teachers interviewed were satisfied with the use of M-learning for the teaching of word problems, and they all agreed on its usefulness, effectiveness and efficiency. However, there were some minor differences of opinions among the teachers on the ease-of-use and on the reliability of the cellular phone application used in the experiment. The novelty of this study can mainly be credited to its focus on the use of cell phone based M-learning for the teaching of word problems, compared to existing literature usually concerned with software applications either for the teaching of algebra and geometry in mathematics or, for teaching in general.**

***Index Terms*—Cellular Phone Application, Homework, M-learning, Word Problems**

I. Introduction

M-learning is a rapidly evolving medium with great potentials for teaching and learning [4]. Some of the benefits of M-learning for learners include; learning anywhere anytime, having fun while learning, improved learning, and quick feedback [4]. According to [12], "the familiarity among younger users makes them an attractive mechanism for incorporating M-learning into the curricular." There are also many benefits for teachers; for example, it gives them an easy way of tracking learners' weaknesses and it makes data capturing easier [4].

M-learning makes use of devices such as Personal Digital Assistants (PDA's), smart phones, laptops, and cellular phones. However, cellular phones are the most popular of these devices worldwide, and they have almost all the capabilities of a computer [4]. Furthermore, cellular phones can be a solution to many educational challenges such as learner independence, motivation, organizational skills, and it gives to learners a sense of responsibility [15]. However, the use of cellular phones for teaching and learning remains in its infancy, and the powerful advanced options offered by this device (text messaging, wireless internet, and visual and audio capabilities) have not yet been explored [7].

There is therefore a need for cellular phone based M-learning to be explored further, and a subject like mathematics is ideal for M-learning, due to its content mainly requiring objective-type questions and answers [12]. It is therefore the aim of this research to examine the use of M-learning by mathematics teachers and learners, specifically for the teaching and learning of word problems.

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II. Problem Statement

Existing literature reports on the availability of effective assistive software for literacy and numeracy [1, 6, 8, 13, and 16]. However, literacy and numeracy at school levels continue to be a major problem worldwide [10]. This might be due to the low level of adoption of assistive software by teachers possibly because "teachers are slow to recognize the benefit of new technology to their learners [16]." Even in the limited cases of technology adoption, the impact of that adoption on learners' performance is not yet optimal as a result of ineffective technology use by teachers. "This is a serious concern especially for difficult subjects such as mathematics where learners' performance is usually low [2]". More so for word problems, a major part of the mathematics curriculum and an area in which learners experience many difficulties, as it requires both literacy and numeracy skills [2].

III. Theoretical Framework

This research is grounded within the theoretical framework provided by the ISO 9241-11 standard on products usability. In this standard, usability is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Context of use is defined in this framework as "users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used [5]".

IV. Literature Overview

It is important to examine existing literature on M-learning in general and specifically for the teaching and learning of mathematics and of word problems. Additionally, it is important to examine existing literature on the adoption of ICT in primary and secondary education in general, and

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specifically for mathematics and word problems. Factors influencing teachers and learners perceptions on the quality of M-learning tools and of other ICT tools are presented in this section, for mathematics and for other subjects. These factors can be summarized by the following attributes: usefulness, performance, efficiency and effectiveness.

Usefulness

A literature review conducted by [15] on the use of cellular phones for teaching and learning in general and for mathematics in specific indicate that cellular phones are a very useful tool for educators, and they are also very popular among learners who find it easy to use and exciting. Similarly, a survey of 98 primary school learners from different schools in Malaysia indicates that M-learning can be useful for general teaching and learning [12]. This finding is also supported by [4, 7, 9, 11, 12, and 14].

Performance

A case study was conducted in a Turkish Secondary School in which a commercial software and teacher designed presentations were used in a mathematics remedial classroom to assess the impact of ICT adoption on learners' performance [14]. Seventy-eight learners from three classes from the Turkish Naval Petty-Officer Preparatory School participated in the study. All learners were given lectures, with only two of the classes receiving additional ICT assistance. The first class was assisted through a Computer Aided Teaching (CAT) software package and they were also allowed to use a commercial software package. The second class was assisted with computer presentations prepared by the teacher. On completion of the lectures, a unique examination was given to all participants. It was found that learners from Class 2 that received teacher prepared presentations were 15.5% more successful than learners from Class 3 that only received lectures. In addition, learners from Class 1 that received CAT and were allowed to use a commercial software package were 18.5% more successful than learners from Class 3 and 3% more successful than learners from Class 2. Similarly, M-learning was also found to improve learners' mathematics performance [11]. An experiment was conducted by [11] whereby 20 learners from a primary school in Malaysia participated. These learners, aged 12, were randomly selected. In the experiment, the selected learners were placed into two groups; the first group named 'mobileM' used 'open source' software called "Mobile Math", the other group named 'traditionalM' used the traditional methods of learning Mathematics. After two weeks, a multiple choice test was given to the participants to assess their performance.

Efficiency and Effectiveness

A review of literature conducted by [9] indicates that ICT offers the following opportunities for the teaching of mathematics: reducing the memory load of learners thereby enabling learners to think more, reducing calculation times for learners; a chance for learners to explore beyond what their teacher may have offered; and a chance for learners to reason, to easily formulate and test theories [9]. Similarly, it was also found through a literature review that mobile wireless devices improve the effectiveness and efficiency of general teaching and learning through the following benefits. Personal Digital Assistants (PDAs) were recognized for their mobility, information management capacity, and beaming capability. Laptops were recognized for their ease of movement, relaxed fit, strategic deployment, low profile, flexibility, cleanliness, convenience, simplicity and speed. Cellular phones were recognized for their freedom of time and location, increased speed in educational processes, and allowances for one-on-one learning [7].

V. RESEARCH DESIGN

The target population for the participants of this study consisted of grade two learners both from urban and rural schools in a developing country. The final sample consisted of approximately 65 learners from three grade two classes from the Kwa-Zulu Natal Province of South Africa. The Kwa-Zulu Natal province of South Africa has approximately 3839 primary level schools. Only 3 schools were conveniently selected for this research due to geographical, time and cost constraints. The following types of schools were selected: a private school and a public school in an urban area, and a public school in a rural area. Thereafter, the principals of these schools chose one class per school to participate in the study. Learners from these classes then participated in an experiment under the instruction of their respective teachers.

A. Experiment Design

Participating teachers' were given permission slips to distribute to the parents of their learners. Only learners with a signed permission from their parents were allowed to participate in the study. Thereafter, a five weeks (school term) experiment was conducted in which teachers were given a cellular phone with a word problem application. Word problems included in the application were chosen by teachers for their class. Because there was only one phone per class, only one learner per day was able to take the phone home. At the end of the experiment, all the participating teachers were interviewed.

B. Software Requirements and Design

The main functional requirement of the application was the computerization of the word problems chosen by the teachers. The purpose of this application was to improve learners' attitude and performance with regard to word problems; and to assist teachers in the teaching of word problems.The following non-functional requirements were expected from the application: usefulness, ease-of-use, effectiveness, efficiency, and reliability.

In the first screen of the application, learners were requested to select the level of difficulty (easy, more difficult, very difficult) corresponding to their aptitude to solve word problems. Learners were then required to solve a word problem of their chosen level of difficulty according to the following three steps: identification of the mathematical

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operator, construction of the expression with the identification of its operands, and calculation of the final answer by the learner. A feedback message was immediately given to learners after each step reached by them. During the three step process described above, learners were not allowed to progress to a next step unless they were successful in the previous step. However, the application includes a feature in which hints were given to learners with incorrect answers. Furthermore, the application included an SMS feature notifying teachers of the level of difficulty chosen by learners, the number of attempts on the choice of operators, the number of attempts on the construction of expressions, and the number of attempts on the calculation of the final answer. This feature was intended to help teachers identify learners' weaknesses. In addition, a similar summary page on the above described SMS content was also displayed on the cellular phone for learners to give them a general idea on their performance. The above described SMS was sent to teachers every time a learner completed his or her homework, or when he or she exited the application prematurely. In the case of learners prematurely exiting the application, teachers were also notified on which question the learner exited at.

C. *Interview Design & Data Collection*

Teachers were formally interviewed at the end of the above described five weeks experiment. This interview consisted of a total of twenty five questions on the following themes: usefulness, effectiveness, satisfaction, efficiency, reliability, and functionality. Most of the questions were open ended to give teachers the chance to fully express themselves. Furthermore, each interview was recorded using a dicta-phone, and these recordings were later transcribed into text for data analysis.

D. *Data Analysis*

Interview data was analyzed according to qualitative content analysis techniques proposed by [17]. In this study, content analysis is used to identify core consistencies and meanings in the interpretation of the transcribed interview data. "Qualitative content analysis involves a process designed to condense raw data into categories or themes based on valid inference and interpretation. This process uses inductive reasoning, by which themes and categories emerge from the data through the researcher's careful examination and constant comparison [17]".

There are three approaches for qualitative content analysis, namely conventional content analysis, directed content analysis, and summative content analysis. Conventional qualitative content analysis is an approach "in which coding categories are derived directly and inductively from the raw data". Summative content analysis "which starts with the counting of words or manifest content, then extends the analysis to include latent meanings and themes". This type of content analysis seems quantitative initially but allows for the inductive exploration of words and or indicators. Directed content analysis is when coding is initiated through a theory or idea before the analysis of the data. In addition, the researcher may also uncover other themes from the data after the initial coding [17]. Directed content analysis was the method chosen by this study for the analysis of teachers' interview data. This analysis was guided by the theoretical framework provided by the ISO 9241-11 standard on product usability. This study was restricted to the examination of the following attributes of the above mentioned ISO framework: usefulness, effectiveness, satisfaction, efficiency, and reliability.

VI. RESEARCH RESULTS

This section presents the results of this study and the inferences that can be made from these results.

A. *Teachers General Impressions*

Interview transcriptions were examined for data relating to 'experiences and suggestions'. For each school, a list of points relating to the teachers' and learners' experiences with the application and general suggestions are presented.

School A

- Learners experienced the use of the application to do homework in a different way in the sense that it was totally different to "pen and paper" based homework.
- Learners' attitudes towards doing homework improved.
- The teacher could see the level the learners were at in their homework.
- The application is not easy for all learners from the start.
- Using the cellular phone gave learners a sense of success and accomplishment.
- The teacher felt that learners should first do homework with pen and paper before using cell phone or laptop.
- The use of the cellular phone application made the learners analyze the question, understand it, and then answer it.
- The cellular phone application is faster than traditional methods for doing word problem homework.
- Learners got to try out word problems on a new medium.
- The cellular phone gave learners a sense of responsibility.
- The use of the application improved the reading ability of learners.
- The teacher could assess the level of the learners.
- Teachers do not have control over whether the learners are getting help or not.

School B

- Learners got to realize that the cell phone could be used for educational purposes and not just for playing games.
- Learners developed an interest in using the cellular phone and got more sums right.
- The SMS's that were sent helped the teacher understand the learners.
- There was an increased involvement by parents in helping learners understand the application.

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- Learners and especially their parents had a problem understanding the application. It should be translated into Zulu.
- There is nothing to think about when working with word problems. Just follow the steps and instructions.

School C

- Learners learnt to work with the problems on a cellular phone.
- Learners got excited and wanted to do more problems with the application.
- The teacher got to see the level the learners were at.
- The use of the application is easy for the learners.
- The use of the cellular phone is an incentive to behave well.
- The cell phone may be used as an additional aid in the class room.
- It is a different way of doing homework
- It takes some time to get to know how to use the cellular phone itself.
- Something very simple should be put in place for the very slow learners.

In general, all three participating teachers found many positive effects with the use of the application by their learners. Some of these were that learners got to try out word problems in a new medium; the use of the application gave learners a sense of responsibility; it increased parents' involvement with homework; it improved learners reading, performance, interest, excitement, and attitudes; it gave the teachers a way of assessing and understanding the competence of their learners; and it reduced the cognitive load for learners when working with word problems. In essence, according to the teachers interviewed the use of the cellular phone based application was of a great benefit to learners when working with word problems. It was clear that this application made a positive impression on the participating teachers and on their attitudes towards any future use of ICTs in their teaching. There were also a few negative comments that should be mentioned: taking control away from the teacher in terms of knowing whether a learner receives help from others, and not having pictures for very slow learners.

B. Themes

The following inferences were made according to the ISO 9241-11 usability attributes.

Usefulness

Teachers who participated in the experiment found the cellular phone application generally useful. The teachers from School B and School A indicated that it was useful because it gave learners an opportunity to experience the concept of word problems in a different way, i.e. using technology. The teacher from School A additionally indicated that the application helped certain learners understand word problems better. Furthermore, the teacher from School B indicated that the application gave learners an alternative use for cellular phones rather than for playing games; and it also gave them the chance to practice mathematics on an exciting medium.

The teachers indicated positivity towards the use of the application in the future. One teacher even wanted the application for class work if available. In contrast, another teacher fancied the application, but for a higher grade, as grade two's are still unstable with word problems. Finally, the experiment has sparked an interest by participating teachers in teaching and learning ICTs. In particular, the teacher from School C even reported that the experiment prompted her to explore more features on her own cellular phone, and she also subsequently began learning how to use a laptop.

Effectiveness

Participating teachers found the application effective for most aspects of teaching and learning. According to these teachers, the cellular phone application was effective in improving the attitudes of their learners. Furthermore, the three teachers indicated that the application created more interest, excitement, and enjoyment among their learners with regard to homework. In addition, two teachers indicated that the application improved learners' performance with word problems. Teachers also indicated that the feedback they received was effective as it revealed the level at which learners were performing. The teacher from School B specifically indicated that the feedback showed areas of learners' weaknesses, for example on operations, expressions, and calculations.

Satisfaction

Participating teachers indicated much satisfaction with the application in general. One teacher even stated, "The fact that they got to take a cellphone home and… and use it, it was a thrill!" Furthermore, the three teachers indicated that learners specifically found enjoyment in using the application; one teacher stated, "They were all fighting who's going to take it home!" Additionally, two teachers expressed positivity towards their general experience with the application. In particular, one educator mentioned that the self-confidence of learners was improved with the use of the application.

Although satisfied with the application, one teacher did mention that grade two learners needed to be given a sound grounding with word problems using traditional methods before being introduced to technology.

Furthermore, the teacher from School A stated that the application was fine just the way it was and that there was no need for changes whereas the teacher from School C wanted to include something for very slow learners, something extremely simple with pictures and graphics. Lastly, the teacher from School B stated that the only change needed was the inclusion of a language selection (multi-lingual application).

Efficiency

In general, participating teachers found the application

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efficient. They felt that using the application did not require too much mental or physical effort from them or from their learners; however one teacher did mention that it was mentally stimulating for the learners. Furthermore, the teachers indicated that using the application was not time consuming compared to traditional methods. One teacher even mentioned that the application may have been faster than traditional methods. Lastly, the teachers indicated that the application required no or little additional resources.

Reliability

Teachers and learners found the application reliable in general. There were no errors mentioned during the use of the application. However, one teacher did allude to experiencing a phone related error. This teacher stated that this error may not even have been an error, but a lack of competency with phones. Furthermore, the system did not crash at any time during the experiment. The teachers felt that the content and structure of the application were suitable for the teaching of word problems. However, one teacher indicated that it was their duty to make their learners understand word problems in specific and mathematics in general. Lastly, teachers indicated that the answers and feedback given to both learners and to themselves were accurate.

C. Demographic Analysis

All teachers were female and none of them reported gender differences in the behavior of their learners during the experiment. It appears that there were some differences in opinions between the teacher from the rural school and the teachers from the urban schools. On the other hand, the public versus private status of a school did not seem to influence the behavior of that school in the experiment.

VII. DISCUSSION

This originality of this study can be attributed to the following three points. Firstly, this study designed and developed its own application for experimental purposes whereas other studies usually use commercial or open source software for experimental purposes. Secondly, this study used cellular phones as a tool for teaching and learning compared to other studies usually focusing on other ICTs such as desktop computers, laptops, and PDAs. Thirdly, this study restricted itself to a specific part of mathematics, namely word problems, generally considered as “an essential and core part of the mathematics curriculum [3]”. Another important aspect of this research is that it is grounded within a solid theoretical framework, the ISO 9241-11 standard on product usability. However, this research is similar to other studies [11, 14] in terms of its methodology: it was based on an experiment, and its data was analyzed using content analysis techniques.

This study has confirmed existing results from other studies on the impact of ICT on learners’ performance, and attitudes for mathematics education in general [4, 9, 11, 12, 14, and 15]. This study has also confirmed that both M-learning and other ICT tools are useful, effective, and efficient for the teaching and learning of mathematics and other subjects [7, 9, 11, and 15].

VIII. CONCLUSION

This paper presents teachers’ perceptions on the ease-of-use, usefulness, effectiveness, efficiency, and reliability of a cellular phone application for the teaching and learning of word problems. This paper also shows that these teachers were satisfied with the use of this application. The results of this study could have implications on the design of M-learning interventions and applications, for mathematics in general and for word problems in specific.

APPENDIX

Usefulness

- Q1. Did you find the cellular-phone-based homework application useful? If yes, for what reasons?

Effectiveness

- Q2. Were there any changes in learners’ demeanors, attitudes, and performance after using the cellular-phone-based homework application?
- Q3. Was the feedback you received from the cellular-phone-based homework application useful to you in assisting your learners?

Satisfaction

- Q4. Was it easy for you and the learners to learn how to use the cellular-phone-based homework application?
- Q5. Thereafter, was the cellular-phone-based homework application easy to use for both you and the learners?
- Q6. Did you and the learners enjoy the experience with the cellular-phone-based homework application?
- Q7. Did you and the learners feel comfortable using the cellular-phone-based homework application?
- Q8. How was both your and the learners experience with the cellular-phone-based homework application in general?
- Q9. Did the cellular-phone-based homework application have any effects on your perceptions on the use of ICT for the teaching of word problems? If yes, how so?
- Q10. Did the cellular-phone-based homework application satisfy your needs as the teacher?
- Q11. In your view, did the cellular-phone-based homework application satisfy the needs of the learners?
- Q22. What were the positives and negatives that you noticed about the cellular-phone-based homework application?
- Q23. Would you use the cellular-phone-based homework application in the future? Please explain your answer?
- Q24. What would you change with the cellular-based-homework application?
- Q25. Has the experiment sparked an interest in you to want to know more about the different ICT’s available for teaching and learning?

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Efficiency

- Q12. Did you feel the cellular-phone-based homework application required too much of a mental or physical effort for yourself or the learners?
- Q13. Was the use of the cellular-phone-based homework application time consuming compared to traditional methods?
- Q14. Was the cellular-phone-based homework application costly?
- Q15. Did the use of the cellular-phone-based homework application require too many resources?
- Q16. Did you find the cellular-phone-based homework application efficient?

Reliability

- Q17. Did you or the learners experience any IT related errors with the cellular-phone-based homework application?
- Q18. Did the cellular-phone-based homework system ever crash?
- Q19. Was the cellular-phone-based homework application reliable?
- Q20. Was the cellular-phone-based homework application inaccurate with any answers or feedback given to the learners or yourself?
- Q21. Was the content and structure of the cellular-phone-based homework application suitable for teaching word problems?

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