UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF GAMES-BASED MOBILE LEARNING MODEL TO TEACH ARITHMETIC AT AN ELEMENTARY SCHOOL IN SAUDI ARABIA

ALKHALDI, IBRAHIM ABDULRAHMAN I

FPP 2022 5

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

April 2021

DEDICATION

This humble work is dedicated to my respected parents, family, friends, and researchers.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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April 2021

Chairman : Othman Talib, PhD
Faculty : Educational Studies

Mathematics teaching and learning is an essential component of the modern educational system. Despite its immense significance, Saudi primary and secondary schools' performance in mathematics has been notably underwhelming. The aim of this study therefore was to design and develop a teaching model that is based on activities for the teaching of arithmetic at the elementary school level. The study was based on Design and Development Research (DDR) proposed by Richey and Klein (2007, 2013) which consists of three phases. Under the Phase 1, needs analysis was conducted through qualitative semi-structured interviews with 16 elementary mathematics teachers particularly teaching under the Saudi system of education. The data collected for the three phases were analysed through thematic analysis and fuzzy Delphi methods. The fuzzy Delphi involved the calculation of the threshold value, 'd' in order to establish experts' consensus on all questionnaire items. In addition, defuzzification values were also generated in order to establish experts' agreement. In accordance with the three phases, the findings of Phase 1 indicated that the elementary mathematics teachers opined that there are problems with the current methods employed in teaching arithmetic at the elementary school level and that employing technology in the form games-based mobile learning will solve issues and problems currently faced in teaching arithmetic at the elementary school level. Phase 2 findings were based on what was gathered from the experts during the NGT sessions that led to the finalization, prioritization and the ranking of the teaching activities. The findings also led to the classification of the activities into four domains, namely introductory domain, contents domain, technology domain, and evaluation domain. As for the findings of FDM Phase 2, the experts reached an overall consensual agreement (d = 93.5) regarding their views on the selected teaching activities (Amax12.867), experts' views on the classification of the teaching activities (Amax13.200), experts' views on the teaching activities under the introductory domain (Amax12.733), experts' views on activities classified as contents domain (Amax13.133), experts' views on the activities classified as technology domain (Amax 12.733), experts' views on the activities classified as evaluation domain (Amax 13.133). Similarly, the experts who participated at the evaluation phase also consensually reached an agreement

among them (d = 93.4). The findings showed that the defuzzification value obtained exceeded the minimum value of 10.5 with the experts' agreement on the domain classification of games-based mobile learning of the obtaining the average defuzzification value (Amax13.100) more than the minimum value of 10.5. The findings of the second aspect of the evaluation questionnaire indicated that the average defuzzification value obtained by the items was (Amax13.126) also more than the minimum value of 10.5. Findings of the study have some far-reaching implications which include the use of both formal classroom teaching and informal learning to help students achieve their learning objectives. In addition, by combining the all the theories adopted and methodological choices made by this study, the findings also have some theoretical and methodological implications including combining all different methodological choices in achieving the study's objectives.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGEMBANGAN MODEL *GAMES-BASED MOBILE LEARNING (GBML)* UNTUK MENGAJAR ARITHMETIK DI SEKOLAH RENDAH DI KERAJAAN ARAB SAUDI

Oleh

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Pengajaran dan pembelajaran Matematik merupakan komponen penting dalam sistem pendidikan moden. Sungguhpun sangat penting, prestasi sekolah rendah dan menengah Arab Saudi dalam matematik sangat kurang memuaskan. Oleh itu, tujuan kajian ini adalah untuk merencana dan mengembangkan model pengajaran berdasarkan aktiviti pengajaran aritmetik di peringkat sekolah rendah. Kajian ini berdasarkan Penyelidikan Reka Bentuk dan Pembangunan (DDR) yang dikemukakan oleh Richey dan Klein (2007, 2013) yang terdiri daripada tiga fasa. Di bawah Fasa 1, analisis keperluan dilakukan melalui wawancara separa berstruktur kualitatif dengan 16 orang guru matematik sekolah rendah khususnya yang mengajar di bawah sistem pendidikan Arab Saudi. Data yang dikumpulkan daripada temu ramah tersebut dianalisis melalui analisis tematik dan kaedah Fuzzy Delphi (FDM). Kaedah Fuzzy Delphi melibatkan mengira nilai ambang, 'd' untuk mendapatkan kata sepakat pakar mengenai semua bahan soal selidik. Di samping itu, nilai yang defuzzifikasi juga dihasilkan untuk mendapatkan kesepakatan pakar. -Berdasarkan tiga fasa tersebut, penemuan Fasa 1 menunjukkan guru matematik sekolah rendah berpendapat bahawa terdapat beberapa masalah dengan kaedah semasa yang digunakan dalam mengajar aritmetik di peringkat sekolah rendah dan penggunaan teknologi dalam bentuk pembelajaran mudah alih yang menyeronokkan dapat menyelesaikan isu dan masalah yang dihadapi semasa mengajar aritmetik di peringkat sekolah rendah. Penemuan Fasa 2 adalah berdasarkan dapatan yang dikumpulkan daripada pakar-pakar selama sesi NGT yang mengarah kepada penyelesaian, pengutamaan, dan peringkat aktiviti pengajaran. Penemuan ini juga menyebabkan pengkelasan aktiviti menjadi empat domain, iaitu domain pengantar, domain isi, domain teknologi, dan domain penilaian. Berkenaan dengan penemuan FDM Fasa 2, para pakar mencapai kesepakatan secara keseluruhan (d = 93.5) merujuk kepada pandangan mereka mengenai aktiviti pengajaran yang dipilih (Amax12.867), pandangan pakar mengenai klasifikasi aktiviti pengajaran (Amax13.200) , pandangan pakar mengenai aktiviti pengajaran di bawah domain pengenalan (Amax12.733), pandangan pakar mengenai aktiviti yang dikelaskan sebagai domain kandungan (Amax13.133), pandangan pakar

mengenai aktiviti yang dikelaskan sebagai domain teknologi (Amax 12.733), pandangan pakar mengenai aktiviti yang dikelaskan sebagai domain penilaian (Amax 13.133). Begitu juga pakar yang mengambil bahagian dalam fasa penilaian juga secara konsisten mencapai persetujuan sesama mereka (d = 93.4). Hasil kajian menunjukkan bahawa nilai defuzzifikasi yang diperoleh melebihi nilai minimum 10.5 dengan persetujuan pakar mengenai pengkelasan domain model pembelajaran mudah alih yang menyeronokkan dengan memperoleh purata nilai defuzzifikasi (Amax13.100) melebihi nilai minimum 10.5. Penemuan aspek kedua daripada penilaian soal selidik menunjukkan bahawa purata nilai defuzzifikasi yang diperoleh daripada bahan (Amax13.126) juga lebih tinggi daripada nilai minimum 10.5. Hasil kajian mempunyai beberapa implikasi yang luas merangkumi penggunaan kedua-dua pengajaran kelas formal dan pembelajaran tidak formal untuk membantu pelajar mencapai objektif pembelajaran mereka. Tambahan pula, dengan menggabungkan kesemua teori yang diterima pakai dan pilihan metodologi yang dibuat oleh kajian ini, penemuan ini juga mempunyai beberapa implikasi secara teori dan metodologi termasuk menggabungkan semua pilihan metodologi yang berbeza untuk mencapai objektif kajian.

ACKNOWLEDGEMENTS

"In the name of Allah, the Most Gracious, the Most Merciful"

First, I should thank Allah the Almighty for giving me blessings as well as the health and strength to finalise this thesis.

I would not have been able to carry out this research project had it not been for the generous help I received from a number of kind people. I would, therefore, like to express my gratitude to the following people:

I am particularly grateful to my lovely parents, brothers and sisters. Without their prayers and support, I would not have reached this stage in my life. Thank you for giving me constant support, encouragement, advice, wisdom and most importantly love.

I express my sincere thanks to my dissertation supervisor Dr. Othman Talib. He gave mein valuable support, time, guidance, patience and great expertise. He showed me the ropes and brought me out on the other side with a good understanding of what quality and quantityresearch is. Had it not been for his invaluable support andencouragement, I would not have been able to complete this study. He was always ready at any time with kind words and wisdom to calm situations, Iam grateful to you. Thank you.

I would like to extend my thanks to my dissertation committee members Dr. Othman Talib, Assoc. Prof. Habibah Binti Ab Jalil and Dr. Nurzatulshima BT Kamarudin for their constructive comments and invaluable feedback throughout the whole project. Their comments and suggestions provided me with good ideas and helped me to improve mywork; this contribution has resulted in the good quality of the thesis. You helped me so much and your thoughts were always well thought out and to the point. I truly appreciate everything you did for me over the years. Both of you I say thank you very much. I am also very grateful to my best friend, Abdulmalik Sabitu and Abubakar A. Usman, who helped me in numerous ways during various stages of my PhD.

I would like to thank my lovely wife, sons and daughters, Dear Hend, Abdulrahman (son), Lattifa and Aljazi (daughters). Without my wife's support and encouragement, I could not have finished this work. It was you who kept alive the fundamental so four family, and I understand it was difficult for you taking care of the family while I was busy. Therefore, I want to say thanks for everything and may Allah give you the best in return.

Finally, I would like to acknowledge everyone who has assisted me throughout my doctoral studies over the years.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Declaration by Members of Supervisory Committee

This is to confirm that:

- The research conducted and the writing of this thesis was under our supervision;
- Supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

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LIST OF ABBREVIATIONS

AECT	Association for Educational communications and Technology CD
DDR	Design and Development Research
GAME-BASED LEARNING	Game-based learning
FDM	Fuzzy Delphi Method
GBL	Game-based learning
GDP	Gross Domestic Product
ICT	Information Communication Technology
LCD	Liquid Crystal Display
MESA	Ministry of Education in Saudi Arabia
MKO	More Knowledgeable Other
NAECTE	National Association of Early Childhood Teacher Educators NCTM
NGT	Nominal Group Technique
P	Participant
PDA	Personal Digital Assistant
ROM	Read Only Memory
SAMR	Substitution, Augmentation, Modification, & Replacement SR
STEM	Science, Technology, Engineering, and Mathematics TIMSS
ZPD	Zone of Proximal Development

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The recent trend in education has been filled with the incorporation education and technology which is not surprising given the fact that technology is ever moving itself to the center of human activities and interaction. In recent years, the advent of new technologies in communication, media and computing have researchers, policy makers, and educators thinking about how to employ them in enhancing educational outcome (Amiel & Reeves, 2008; Spencer, 2017). Numerous forms of technology (such as Edison's film projector, and Berners-Lee's World Wide Web) were quickly studied and adopted in educational processes (Domingo & Garganté, 2016). Currently, there are various modes of educational technology ranging from distance learning, e-learning, mobile learning, and mobile game-based learning. The advent of the Internet, particularly web 2.0, has been a profound revolution in terms of instruction, teaching and learning (Amiel & Reeves, 2008; Shatunova et al., 2019). This is because the Internet enables a virtual two-way communication among learners and between learners and instructors and so on.

Currently, most of basic subject of education can be taught and learned through variety of technological tools. The subject of mathematic is considered one of the most important subjects in the modern educational system. Mathematics teaches human how to count without which the life of human will be inexplicable. Without mathematics it will be impossible to count even in relation to the most mundane things such as knowing the number of members of a family, number of pupils in a class, or the little amount of money we keep in our wallets. Thus, at a very basic level, human must be able to do the basic of arithmetic of adding, subtracting, multiplying and dividing. Studies have shown the necessity of mathematics skills right from the early age as it is linked with problem solving, critical thinking ability, teaches the skill of the everyday data interpretation and manipulation in addition to numerous other benefits that are often linked to it (Clemson & Clemson, 2006; Solórzano et al., 2018).

The realization of this salient significance of mathematics makes it one of the compulsory subjects at the elementary level in the modern system of education throughout the world (Solórzano et al., 2018). Mathematics has become the foundation of various fields of knowledge that include physics, engineering, economics, business and medical sciences. Mathematics has been recognized as the foundation of science, technology and intellectual development and is also an index of civilization evolution (McDonald, 2016). The high demand of mathematics knowledge for effective implementation of other science, technology, engineering, and mathematics (STEM) disciplines right from the elementary level is owing to the nature and properties of mathematics as a subject. A good understanding of mathematics at elementary level can

offer both thinking and computational skills that can be of great significance in the understanding of other subject at higher level (Aunio et al., 2016).

The increasing relevance of science, technology, engineering, and mathematics (STEM) education in recent years could be perceived as the reason for the challenge to have an alternative innovation and change in mathematics instruction especially in elementary classrooms (Guzey et al., 2017; Moore et al., 2014). This presents challenges for mathematics educators who are expected to contribute to the foundations of integrating educational technology for the implementation of STEM education to produce a STEM literate community. According to Stohlmann et al. (2012), STEM education is vital for the future success of students. For this success to be realized, there is need for the effective teaching of the STEM subjects using the most advanced technologies (Nersesian et al., 2019).

The continuous evolution of educational technology in mathematics education is an issue that has been discussed and is still generating more discussion from various stakeholders (Drijvers, 2015; Viberg, Grönlund & Andersson, 2020). The National Council of Teachers of Mathematics (NCTM) has made its position clear on the immense potential of educational technology in mathematicS education stating that "Technology is an essential tool for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology" (NCTM, 2000). However, as empirical studies show that even in advanced nations that are identified as leaders in mathematics and mathematics education (such as Sweden), mathematics teachers use digital technology less than their counterpart in other subjects (Viberg, Grönlund & Andersson, 2020). If anything, this reveals the need for more research in the area of educational technology mathematics education. According to Stohlmann et al. (2012), STEM education is vital for the future success of students. For this success to be realized, there is need for the effective teaching of the STEM subjects using the most advanced technologies (Nersesian et al., 2019).

1.2 Statement of the Problem

For decades, improvement in educational technology has been identified by the Kingdom of Saudi Arabia as the most important area that the country needs in order to catch up with the most advanced countries in education (Alqarni, 2015). Emphasis was put on educational technology in the Kingdom's national plans (1975-1980), (1980- 1985), (1985-1990), as was made clear by the former Deputy Minister of the Ministry of Education, Abdel-Wassie, in his book (Alqarni, 2015). Now more than ever before, with the boom of information system and the rise of new generations of learners who are keener and more technology savvy, the Kingdom has placed more earnest emphasis on more inclusion of technology in the country's system of education (Al-Emran, Mezhuyev & Kamaludin, 2018).

However, in spite of the Kingdom's seemingly early identification of the significance of educational technology in ensuring that its citizens enjoy the best education products any

country can offer, there has not been notable improvements (especially at the lower education level in mathematics and science related subjects) particularly when compared with more advanced countries (Alghamdi, 2018; Abouelnaga et al., 2019). According to the recent report issued by the Trends in International Mathematics and Science Study (TIMSS), Saudi Arabia spends a greater share of its gross domestic product (GDP) on education more than most wealthy countries. Yet, analysis of the trend in performance of pupils between 2011- 2015 of the 41 countries listed Saudi Arabia along four other countries like Finland, Germany, Kuwait and Netherlands among countries with lower average achievement in mathematics and science for pupils in grade 4 and 8 (Alghamdi, 2018; Mullis et.al., 2015). Moreover, the report also showed that, the percentage of Saudi pupils with low achievement score exceeds 15 percent and 25 percent for 4th and 8th grades respectively. This indicated that only 50 percent of Saudi pupils (13-year-old) reached the lowest benchmark compared to 99 percent in South Korea and 88 percent in England.

However, a few studies (Alzahrani, 2017; Mansour Alabdulaziz & Higgins, 2017) showed that the performance of pupils in mathematics is consistently poor and discouraging especially at elementary level. Recent studies by Alshehri (2012) Alyahya and AlOtaibi (2019) attributed the problem to the abstract nature of the subjects that made it difficult to be learned by the pupils. Similarly, Alsuwidan (2018) argued that the main reasons for the weak competence and low performance among the pupils in elementary schools in mathematics is because mathematics is introduced, represented and illustrated to the pupils in elementary school with conventional methods which make the pupils less sensitive and less attentive. Furthermore, the traditional mathematics instruction has been based on certain procedures, doing exactly what mathematic teachers want their pupils to do i.e., memorizing logarithms as well as finding the correct answers (Yelland, 2015).

It is in view of the above that the Saudi Ministry of Education (MESA), like other countries across the world, started to encourage the integration of information technology in education through design and development of mobile-learning applications to provide interactive learning experiences for the elementary school pupils. The aim is to make some critical subjects like mathematics, basic science and technology and foreign languages more attractive and understandable for the pupils (Al-Fahad, 2009). The Ministry has recently made an unprecedented commitment towards STEM education with the view of using technology to achieve the target goals (Aldahmash, Alamri & Aljallal, 2019).

Educational mobile applications are regarded as the model of e-learning (Squire & Dikkers, 2012; Ellis, Stam, & Lizardi, 2019). The mobile-learning applications are also viewed as fulfilling particular psychological devices for the pupils, especially at the elementary school stage (Chan & Kong, 2011). Mobile-learning applications are also found as a potential assistance for the elementary pupils as well as a way of motivating and simulating pupils to understand. More importantly, they embody experiences and problem solving skills especially for mathematics and languages acquisitions (Alharbi & Drew, 2014). However, as argued in the previous paragraphs, students' performance continues to suffer despite the use of e-learning and mobile learning as solutions.

Therefore, the solution to the dwindling students' performance particularly in mathematics lies in employing mobile technologies to support the existing conventional classroom teaching and learning (Alzahrani, 2017). The use of mobile devices have attracted the attentions of researchers around the world as they are perceived as integrated devices within the learning and teaching methods and processes (Jusoh, Salam, & Sayuti, 2012).

Another form of learning that can improve pupils' performance in subjects like mathematics is game-based learning. It is a type of learning that is carried out through the use of games that have some educational value or perhaps using various forms of software application for the educational purposes of learning effectiveness (Huang, Chang & Wu, 2017). While game-based learning has been around for sometimes now, it is just recently that scholars have begun coupling mobile learning and game-based learning together. This was described by Park (2011) as the next generation form of mobile learning that will come into full effect once both instructors and learners realize the significance of technology usage in the process of teaching and learning. The problem is while mobile learning is likely to help in solving the existing problems in relation to mathematics teaching and learning, however, when dealing with children the element of game is needed in order to help them achieve their learning objectives (Prensky, 2001). It is linked with the quality of improving students' problem solving ability and critical thinking because of its active engagement of the brain in a way that prompt problems and require a swift solution (Pivec et al., 2003; Coştu et al., 2009).

The use of mobile game-based learning for the teaching of arithmetic is likely to solve the many problems encountered using conventional methods of teaching. Researchers like (Chang et al., 2012; Naik, 2014) reported the use of games in teaching can attract the pupil's attention in the learning of mathematics. He added that digital game-based learning can provide pupils with a more interesting environment to learn. This shows that games are really loved by the pupils and also make learning more interesting. Researchers (Ke, 2008a; 2008b) have demonstrated that games have the potential for creating learning environments toward the improved attainment of educational and training goals. Similarly, scholars have established that game-based learning is excellent at attracting learners' attention, heightening concentration and making learning experience joyful and fun, as well as achieving learning objectives effectively (Cheng & Su, 2012; Serrano, 2019). Game-based learning was found to have effect on students' attitudes toward mathematics in a positive manner. In addition, students also showed positive attitude towards the use of game-based learning in mathematics classes (Coştu et al., 2009). Furthermore, it was also found by a few studies to have impact on the achievement of learning goals; the motivation for learning mathematics (Divjak & Tomic, 2011); improve memory, attention and executive control; cognitive skills; mental rotation skills (Drigas & Pappas, 2015); higher learning gains compared to traditional classroom instructional methods (Tokac et al., 2019). However, the problem is the use of conventional classroom-based learning which does not take advantage of the availability and centrality of mobile devices to the current generations of learners. In this study, comprehensive sets of models have been integrated along with a detailed explanation of each model. The proposed mobile application will comprise of game-based learning (GBL), multimedia learning theory and cognitive development theory. Each of these models and theories adopted is helpful but not sufficient in providing a

well-guiding framework for the development of the model. It is by combining these models and theories that a more coherent and holistic framework can be established in developing the implementation model. This is therefore theoretical gap that this study aims to fill and contribute to the extant literature.

Thus far, there has not been studies on the implementation model for the integration of mobile and game-learning together for the teaching and learning of mathematics particularly in the context of Saudi Arabia. This is so despite the immense significance attached to mathematics education by the Saudi government and its explicit desire and commitment to ensure that Saudi students excel and can compete with the best countries in terms of mathematics education and skills. However, since this may not be sufficient a justification for the development of the implementation model for the integration of mobile and game-based learning to the traditional classroom-based teaching and learning, this study is set to establish the need of the model first by interviewing Saudi elementary schools' mathematics teachers. Only after establishing the teachers' perception the need for the model, the study embarks on the design and development of the actual model. This study therefore intends to develop a game-based learning model for the teaching of arithmetic at the Saudi elementary school level.

1.3 Objectives of the Study

1. To explore mathematic teachers' perceptions on the need to develop game-based learning model for the teaching of elementary mathematics of the Saudi Schools. This objective consists the following specific objectives:

    i. To explore mathematics teachers' perceptions on the conventional methods used for the teaching of elementary at the Saudi Schools.

    ii. To determine mathematics teachers' (readiness) willingness to use game-based learning model for teaching mathematics at the Saudi elementary level.

These objectives are expected to offer justification for the need to development game-based learning application for the teaching of arithmetic at the Saudi elementary schools. This is inline with what was indicated above under the problem statement on the lack of previous studies on a model that integrate mobile and game-based learning.

2. To develop game-based learning model for the teaching of mathematics at the elementary level of Saudi Schools based on experts' views and decisions. This objective consists the following specific objectives:

    i. To use experts' collective opinions on the teaching activities that should be incorporated into the development of the game-based learning model.
    ii. To use experts' collective opinions on the classification of the teaching activities included in the Game-based learning model for the teaching of arithmetic.

The aim of these objectives is to address the problem of monotony, boredom, and poor performance in mathematics as highlighted above under the problem statement. Development of the model should help in improving students' performance and reducing the boredorm and monotony often associated with mathematics learning.

3. To evaluate the game-based learning model for teaching mathematics at the elementary level of Saudi Schools based on experts' views and decisions. This objective consists the following objectives:

    i. To seek experts' agreement on the suitability of the game-based learning model activities proposed at the development stage for the teaching of mathematics at Saudi elementary schools.

    ii. To seek experts' agreement on the type of the game-based learning model activities based on the four domains (Introductory domain, Contents domain, Technology domain, and Evaluation domain) proposed in the game-based learning model for the teaching of mathematics at the elementary school.

1.4 Research Questions

On the basis of the problem statement and the research objectives, this study raised a number of questions according to the three phases earlier stated which is based on design and development research approach, as to be extensively explained later in the research methodology chapter. The following are the questions raised with regard to phase 1 which is ascertaining the needs for the development of a game-based learning model for the teaching of mathematics at Saudi elementary schools:

RQ 1.1 What are mathematics teachers' perceptions on the current methods used for teaching elementary pupils in Saudi Schools?

RQ 1.2 What is mathematics teachers' level of readiness to use game-based learning model for teaching mathematics at the Saudi elementary schools?

The following are the questions raised with regard to phase 2 which is developing the game-based learning model for the teaching of mathematics:

RQ2.1 What are the experts' collective opinions on the teaching activities that should be incorporated into the development of the game-based learning model?

RQ2.2 How should the learning activities be classified in the interpretation of the game-based learning model based on the experts' collective opinions?

F-or the final phase, phase 3, that is evaluating the game-based learning model of teaching mathematics at the elementary level based on the experts' opinions. The following questions have been raised:

RQ3.1 What is the experts' agreement on the suitability and usability of the mobile learning teaching activities proposed in the game-based learning model for the teaching of arithmetic at the elementary level?

RQ3.2 What is the experts' agreement on the classification of the game-based learning model teaching activities based on the four domains (introductory domain activities, contents domain activities, technology-based domain activities and evaluation domain activities) proposed in the game-based learning model of teaching mathematics at the elementary level?

1.5 Significance of the Study

The salient role of mathematics knowledge socially and intellectually justifies the need for more effective and up-to-date teaching approaches that will make learning of mathematics appealing to pupils starting from the elementary level. This study sheds more light on educational technology, thereby contributing to practical, theory, and body of knowledge. As indicated earlier under the problem statemenet, the Saudi government has identified the need for the increase use of educational technology in its educational system particularly in relation to teaching mathematics and other science-based subjects (Al-Emran, Mezhuyev & Kamaludin, 2018; Alqarni, 2015). Therefore, findings of this study are expected to have some significant implications for pupils, teachers and curriculum designers in education technology as well as mathematics education. In addition, findings of this study are expected to have a great significant to explore the role of mobile and game-based learning through the development of the game-based learning model to enhance student performance in elementary mathematics.

Similarly, with the poor students' performance in mathematics, as highlighted by some studies (Alzahrani, 2017; Mansour Alabdulaziz & Higgins, 2017), which has been attributed to the abstract nature of mathematics subject (Alsuwaidan, 2018; AlOtaibi, 2019), the model set to be developed by this research is expected to improve students' performance in mathematics. The findings are also expected to minimize the abstract nature of mathematics using audio-visual elements of video and computer games.

The model is expected to work as a guide for the design of a mobile application in the form of game to support teachers and pupils in teaching and learning, leveraging on the ownership of mobile devices due to their ubiquitous nature and affordability for most people. The findings of this study are, therefore, expected to provide an alternative way of looking at pupils' performance through a mobile game-based learning with the hope that curriculum designers will include fun driven mobile learning as one of the keys to improving pupils' performance of pupils in the future in designing curriculum contents especially for elementary mathematics concepts. However, the aim of the game-based learning model is not to suggest a substitution to the formal classroom learning. Rather, the aim is to support and augment the formal classroom learning by introducing an element to the teaching of arithmetic that will galvanize pupils' interest and consequently result in the improvement of their performance and the love for learning mathematics. Saudi students' performance has been getting worse despite Saudi authorities' heavy

investment on mathematic education along other STEMS subjects (Alqarni, 2015; Al-Emran et al., 2018). However, no significant progress has been so far recorded and students continue to have poor achievement in mathematics education. Extant literature has reported the positive effect mobile and game-based have in making mathematic learning fun, motivate students and improve their, memory, retention and understanding, performance and achievement in mathematics (Divjak & Tomic, 2011; Drigas & Pappas, 2015; Tokac et al., 2019).

Furthermore, the findings of this study will contribute to the benefits of the Saudi society considering that mathematics plays an important role in science and technologies today. The findings are likely to show how administrators will be guided toward the incorporation of technology in the school curriculum to improve pupil's performance in mathematics. For the researchers, the study will help them uncover critical areas in the educational process that many researchers were not able to explore. Thus, a new theory on learning mathematics may be arrived at. Likewise, at the state level, the Ministry of Education in Saudi Arabia is also likely to find findings of this study beneficial and use it in revolutionizing the curriculum and hence the teaching and learning of mathematics in the Kingdom of Saudi Arabia. This may also go to the great length of helping administrators of education in other countries particularly the developing countries like the Kingdom of Saudi Arabia to adopt similar reform providing that they show positive outcome with regard to teaching and learning mathematics in the Kingdom of Saudi Arabia.

This study is also expected to contribute theoretically to the extant literature. Theories and models of mobile learning, game-based learning and mathematics learning are all disparate and individually insufficient in providing a framework for this type of study. By combining and integrating them in the way this study looks to do, however, a new theoretical or conceptual framework has been developed which can be used by similar future studies. This study, therefore has a theoretical significance to the extant literature.

1.6 Scope and Limitation of the Study

The model for the games-based mobile learning was developed using technology related activities for teaching elementary school mathematics only. This study is limited to the development of model for the teaching basic arithmetic concept such as Addition, subtraction, division and multiplication to the elementary level pupils. It is not within the scope of this research to develop the application itself. Doing so is left to the future studies that might be interested in the topic to use this study as a guide for the development of the mobile application itself. In addition, this study limited to the elementary stage arithmetic. Its findings may not applicable to the other stages of education such as the secondary and tertiary levels. The findings may not also be suitably applicable to the contexts of other subjects teaching and learning. In a nutshell, the findings of this study are not meant to be generalized to all contexts of the mathematics teaching and learning, other stages of education and/or the teaching and learning of other school's subjects. Although the findings of this study are specific to the context of this

research and may not be applicable in all contexts, they can be implied or replicated in other contexts where they may be fit.

1.7 Definition of Key Terms

This section defines some of the key terms as they are used in the context of this study. They are as follows:

1.7.1 Game-Based Learning/Fun Learning

The term fun learning or fun-based learning are two words of fun and learning married up together. Fun is defined as a social emotional interactional process through which a person deconstructs social-biographical inequalities in order to create a social-human bound with equal other (Podilchak, 1991). The term fun learning is used to refer to an approach to education that focuses on nurturing the passion and initiate the feeling of joy while engaging in learning (Lucardie, 2014). The term also refers to the opposite of conventional learning approach that are usually described as being monotonous and boring. Thus, fun learning is employed in this study to mean learning through games and plays and other means considered means of fun and recreation. In the context of this study, fun learning is used to refer to a casual approach to learning where pupils engage in learning process using digital game plays designed specifically to teach the pupils arithmetic. For example, this can be achieved by designing a mathematics gaming application which is structured according to the Saudi elementary school mathematics syllabus.

1.7.2 Mobile Learning

Mobile learning can be simply defined to mean a type of learning that is carried out with the aid of mobile devices or some forms of mobile computing intersection (i.e. a small application, portable and wireless computing or communication devices) (Quinn, 2012). The term mobile learning is also used to mean the ability to get or offer educational contents on devices such as PDAs, smartphones, and mobile phones. According to Lehner, Nosekabel and Lehmann (2003), there are three layers of mobile learning. The first of the layers is components of mobile education that include students, teaching staff, administration and education system. The second layer is the application layer that enables communication among learners, teachers and the learning content. The layer is the database which stores the main resources of mobile learning. They added that mobile learning facilitates learning in four different ways:

1. It connects students with lecturers, notes, or learning materials on mobile technologies for the sake of knowledge acquisition.
2. It is used to manage students' learning process by posting and updating information through Learning Management System (LMS).

3. It provides active communication services both asynchronously and synchronously which are done through pull and push technology to scaffolding learning.
4. A cost effective and reliable means of monitoring students' learning progress.

In this study, the term mobile learning is used to refer to learning and practicing mathematics activities using digital devices such as smart mobile phones, tablets, laptops, e-readers, handheld gaming consoles and so on.

1.7.3 Elementary Mathematics

Elementary learning is the first level of public education which comprises six grades (1-6). Pupils' ages of the school are from 7 to 12 years old and the duration for each grade is one year. In this period, students learn the basic principles and rules of several different subjects and materials as diverse as the Quran, Islamic Studies, Science, Mathematics, Arabic language, History, and Geography. The term elementary mathematics is usually used to refer to mathematics topics most frequently taught at the lower school education (primary or secondary school levels). Elementary mathematics consists of five basic strands namely numBer sense and numeration, measurement, geometry and spatial sense, patterning and algebra, and data management and probability (Ontario Ministry of Education, 2005). This study focuses on the first strand, number sense and numeration, in designing and development a game-based learning model for the teaching of arithmetic at the elementary school level.

1.8 Organisation of the Study

This study is organised in seven chapters with each chapter focusing on an important aspect of the study.

Chapter One, titled Introduction, is designed to introduce the topic of the research by providing a background to the problem, discussing the problem itself, the objectives of the study, the questions to be used in guiding the research, its significance, and eventually summarizing the entire chapter.

Chapter Two, titled Literature Review, provides a research context for the current study. The chapter discusses all the major concepts of the study, reviews empirical studies previously carried out in relation to the topic under study, and presents theoretical framework and eventually the conceptual framework of the study.

Chapter Three, titled Methodology of the Study, presents the methods selected in conducting the research. Since this study employs a design and development research (DDR) approach, the chapter is divided into three major sections according to the three

phases of DDR namely, needs analysis phase, design and development phase, and finally evaluation phase.

Chapter Four, titled Findings, is divided into three phases. Phase 1 presents the findings of the needs analysis. This phase discusses the findings of the first of the three phases of the research, the needs analysis phase, by analyzing the interviews conducted with sixteen elementary school mathematics teachers under the Saudi system of education. Phase 2 focuses on the Model Development. It is the phase where the model is developed and presented. This phase is the soul of the findings of the research since the major purpose of the study is to develop a game-based learning model. Phase 3 is Model Evaluation. In this part, findings of the evaluation phase which is carried out through fuzzy Delphi method are presented.

Chapter Five, titled Discussion and Conclusion, discusses the findings of the study in relation to the extant literature and theoretical underpinnings of the study. It is the section that interprets the findings of the study. This is followed by a summary of the findings made, then concluding the research, discuss its implications and then offer some useful recommendations for future studies.

1.9 Summary

The intention of this chapter is to lay foundation to the rest of this study. The chapter discusses the background of the study, presents its problems, research objectives and questions before eventually discussing its significance and scope of the study. The chapter also provides definition of key terms as they are used in the current study. The rest of this study is designed to follow on the map laid down herein this chapter.

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