Malaysian Journal of Social Sciences and Humanities (MJSSH)

Volume 6, Issue 12, December 2021

e-ISSN : 2504-8562

Journal home page:
www.msocalsciences.com

The Application of Fuzzy Delphi Method (FDM) in the Development of Fun-Driven Mobile Learning (FDML) Model for Teaching of Arithmetic in Saudi Schools

Ibrahim Abdul Rahaman Alkhaldi¹, Othman Talib², Nurzatulshima Kamarudin²,
Habibah Abduljalil³, Abdulmalik Sabitu⁴

¹Department of Education, Ministry of Foreign Affairs of Saudi Arabia, Saudi Arabia

²Department of Science and Technical Education, Universiti Putra Malaysia (UPM), Malaysia

³Innovative Learning Sciences Research Centre of Excellence (INNOVATE) Faculty of Educational Studies
Universiti Putra Malaysia (UPM), Malaysia

⁴Department of Science Education, Federal University Dutsin-Ma, Katsina, Nigeria

Correspondence: Ibrahim Abdul Rahaman Alkhaldi (Ib.math@hotmail.com)

Abstract

One of the methods used in Design and Development Research (DDR) is the Fuzzy Delphi Method (FDM). It is a systematic method for the development and validation of the model. This article aims to use this method to validate a Fun-Driven Mobile Learning (FDML) Model for Teaching Arithmetic. In phase 1 of design and development research, based on the opinion of teachers as subject matter experts, the need to develop the FDML model was justified. In phase 2, the model developed, comprised of thirty-two teaching activities grouped into four clusters. This article presents results on suitability and overall usefulness of the model components derived from the collective opinion of the 15 experts involved in Phase 3 of the study. The data analysis was conducted through the fuzzy Delphi method using a 7-point Likert scale. The outcome indicates a consensus of 93.4 percent of experts at a threshold value of ≤ 0.02 . The suggested components of the FDML model include an integral planning reference for the application of the model and provided alternative validation procedures for model developers in mathematics education and educational technology.

Keywords: Fuzzy Delphi Method, mobile learning, learning with fun, game-based learning

Introduction

For decades, improvement in educational technology has been identified by the Kingdom of Saudi Arabia as the most important area that the country needs 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, Mezhyuev & Kamaludin, 2018). However, despite 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 have not been notable improvements (especially at the lower education level in mathematics and science-related subjects) particularly when compared with more developed countries (Alghamdi, 2018; Abouelnaga et al., 2019).

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 the 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 for students to learn. Similarly, Alsuwidan (2018) argued that the main reasons for the weak competence and low performance among the pupils in elementary schools in mathematics are that, 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, 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).

Therefore, this study intends to validate an FDML model developed for the teaching of arithmetic at the Saudi elementary school level. This study aims to validate the FDML model for the teaching of mathematics at the elementary school level. The evaluation process is to be undertaken by a group of experts who would decide the arithmetic teaching activities proposed and integrated into the model, the relationship between the activities, and whether or not the model is suitable based on the elements included. The process of evaluation will be conducted through the fuzzy Delphi method to help in stimulating experts' views on the appropriation of the model. The following paragraphs elaborate on the method, the instruments used, the selection of experts, the procedure of the evaluation as well as the analysis of data. To seek experts' agreement on the classification of the FDML model activities based on the four domains (Introductory domain, Contents domain, Technology domain, and Evaluation domain) proposed in the FDML model for the teaching of mathematics at the elementary school.

Contextualising the Study

The Saudi Ministry of Education (MESA), like other countries across the world, started to encourage the integration of information technology in education through the design and development of mobile-learning applications to provide interactive learning experiences for elementary school pupils 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 potential assistance for the elementary pupils as well as a way of motivating and simulating pupils to understand and more than that, they embody experiences and problem-solving skills especially for mathematics and language acquisitions (Alharbi & Drew, 2014). With all the potential solutions e-learning and mobile learning are proven to offer and while the world is increasingly becoming entrenched in technology, teaching and learning continue to be carried out through conventional methods. As a result, as proven in the previous paragraphs, students' performance continues to suffer.

However, as seen by various researchers, the solution to the dwindling students' performance particularly in the subject of mathematics lies in employing mobile technologies to support the existing conventional classroom teaching and learning (Alzahrani, 2017). Therefore, the use of mobile devices has attracted the attention of researchers around the world which are perceived as integrated devices within the learning and teaching methods and processes (Jusoh, Salam, & Sayuti, 2012). The same could also be said of e-learning which superseded the advent of mobile learning. Mobile learning was only made possible through e-learning as mobile devices often require some forms of connectivity (such as the Internet) for them to function (Ozuorcun & Tabak, 2012). Parallel to mobile and e-learning, game-based learning has been recently attracting quite a great number of scholarly attentions. 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 issue is that, while mobile learning is likely to help in solving the existing problems concerning mathematics teaching and learning in dealing with children the element of the game is needed to help them achieve their learning objectives (Prensky, 2001).

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. Chang et al., (2012) and Naik (2014) reported that 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 the learning experience joyful and fun, as well as achieving learning objectives effectively (Cheng & Su, 2012; Serrano, 2019). Also, 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 will be integrated along with a detailed explanation of each model to develop a mobile learning model for the teaching and learning of arithmetic using game-based learning (GBL), multimedia learning and cognitive development theories. Mathematics as a system of complex relationships, requires a connection between thinking and reasoning (mathematical thinking), to obtain a more complete understanding of its concepts at the elementary level (Mason, Burton, & Stacey, 2011; Morsanyi, Prado, & Richland, 2018).

Objectives of the Study

The following is the objective aimed to be achieved by this article: To seek experts' agreement on the suitability of the FDML model activities proposed at the development stage for the teaching of mathematics at Saudi elementary schools.

Research Questions

For this article, the following question is raised and set to be answered: What is the experts' agreement on the suitability and usability of the mobile learning teaching activities proposed in the FDML model for the teaching of arithmetic at the elementary level?

Methodology

This research employs the fuzzy Delphi method, which involved decision making on the suitability and usability of the model through experts' collective opinion. A copy of the developed model, all the aspects of its interpretation, and the survey questionnaires are attached and sent to the experts. The reason for doing so is to give the experts time to critically look at all the aspects of the developed model before validation.

This is considered the most important step when using the Fuzzy Delphi method since it can affect the quality of the findings of the study (Taylor & Judd, 1989). The study employs purposive sampling in selecting the 15 experts who are tasked with the evaluation of the model. The reason for selecting 15 experts is because previous studies have no consensus over the exact number to be considered. For instance, Adler and Ziglio (1996) and Gustafson et al. (1975) have all proposed a number ranging between 10 and 15. Likewise, Witkin, Altschul, and Altschul (1995) proposed 10 to 50 experts. Thus, on this basis, this study selected 15 respondents for this phase. However, researchers such as Delbecq, Van de Ven and Gustafson (1975); Mohamad, Embi and Nordin, (2015); Saido et al. (2018) have

completely different criteria. To them, the experts should be categorized into three groups namely, top management who are bound to use the outcome of the study; professional individuals; and individuals whose judgment is obtained. In the case of this study, given the above few criteria suggested by many scholars, the evaluation process will be carried out by curriculum design experts, mathematics education experts, and educational technology experts.

Therefore, the fifteen (15) experts selected comprised of four (4) female, eleven (11) males. Additionally, in terms of their qualifications, eleven (11) of the fifteen (15) were holders of Ph.D., and the remaining three (3) were master's holders and one (1) was a bachelor holder. When it comes to the experts' field of expertise, five (5) of them are specialists in educational technology, seven (7) were specialists in curriculum design (education), and the remaining three (3) were specialists in mathematics education. A survey questionnaire divided into two major sections was the instrument used for data collection. The first section entails experts' details, their opinion on the model. The personal details of the experts are to obtain their background information as well as their use of mobile technologies. The second section is to obtain experts' views on the model. The instrument employed was validated by four (4) curriculum experts and experts on the use of technology for instruction. Furthermore, the instrument was also be subjected to a reliability test for all the items. The data were analysed using descriptive statistics through the fuzzy Delphi method. The results of the analysis were presented and discussed in the findings section.

Findings

Experts' responses were collected through an evaluation survey questionnaire using a seven-point linguistic scale, the threshold value for all the questionnaire items were generated and calculated as in Table 1.

Table 1: Threshold Value 'd' of the Evaluation Survey Questionnaire Items

Experts	Item									
	1	2	3	4	5	6	7	8	9	10
1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1
2	0.1	0.0	0.0	0.0	0.1	0.6	0.2	0.2	0.3	0.1
3	0.1	0.0	0.2	0.0	0.1	0.0	0.2	0.0	0.0	0.1
4	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1
5	0.1	0.2	0.0	0.0	0.1	0.1	0.0	0.2	0.0	0.1
6	0.1	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.3	0.1
7	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.1	0.1
8	0.1	0.5	0.5	0.0	0.1	0.0	0.0	0.2	0.0	0.1
9	0.1	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.1
10	0.1	0.2	0.0	0.0	0.1	0.3	0.2	0.0	0.0	0.1
11	0.1	0.0	0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.1
12	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.1
13	0.1	0.2	0.2	0.0	0.1	0.1	0.0	0.2	0.0	0.1
14	0.1	0.2	0.2	0.1	0.3	0.1	0.1	0.0	0.0	0.1
15	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.1
The Value d of Each Item	0.06	0.13	0.13	0.08	0.09	0.13	0.11	0.09	0.09	0.06
	8	3	3	4	2	1	1	6	4	8

As indicated in Table 1, overall, there were 150 total experts' responses generated from the evaluation questionnaire. The overall threshold value' was calculated using the following formula: $[150 (\text{total experts' responses}) - 141] \div 150 = 93.4\%$. Therefore, the total threshold value was greater than 75% as the minimum threshold value implying that the experts reached the required consensus on their views for all the questionnaire items of the survey evaluation questionnaire employed to evaluate the FDML model for the teaching of arithmetic at the elementary school level under the Saudi system of education.

A threshold value that is not greater than 75% indicates that the fuzzy Delphi has to be repeated and the experts will have to respond to the survey questionnaire again to reassess their opinions. Without reaching a consensus the fuzzy Delphi has to be repeated several times and again until consensus is reached.

The evaluation survey questionnaire was designed to consist of two separate aspects of validation as follows:

- a) Experts' views on the classification of the teaching activities into domains.
- b) The overall usability and suitability of the model of teaching activities in helping the teachers and the pupils fulfil their teaching and learning objectives, respectively.

Experts' Views on the Classification of the Teaching Activities into Domains

This aspect of the questionnaire has five separate items under it. The first item asked the participants the following question: 'Do you agree with the grouping of fun-driven mobile teaching activities into 4 domains as shown in the model: Introductory Activities, Contents Activities, Technology Activities, and Evaluation Activities? This item represents 1.1 in the survey questionnaire. The defuzzification value considered acceptable has to fall between 10.5 (minimum value) and 14.4 (maximum value). The defuzzification value obtained for item 1.1 is indicated in Table 2 to have exceeded the minimum value at 13.500. Therefore, the experts were in consensual agreement on this survey questionnaire item.

Table 2: Experts Views on the grouping of the Teaching Activities of the model into Domains

Item 1.1			
Average responses	0.767	0.933	1.000
Fuzzy evaluation	11.50	14.00	15.00
Defuzzification value		13.500	

As for item 1.2 under this aspect, the experts were asked the following question in the survey questionnaire: 'Do you agree with the list of activities grouped under Introductory Activities as shown in the model? For this item also, the defuzzification value obtained exceeded the minimum value of 10.5 at 12.700 as indicated in Table 3. Thus, the experts consensually agreed on this item as well having reached 93.4 percent total agreement.

Table 3: Experts' agreement on the list of activities grouped under Introductory Activities

Item 1.2			
Average responses	0.700	0.873	0.967
Fuzzy evaluation	10.50	13.10	14.50
Defuzzification value		12.700	

The next question in the evaluation survey questionnaire asked the experts the following: 'Do you agree with the list of activities grouped under Content Activities as shown in the model? This represented item 1.3 in the questionnaire survey. The defuzzification value also obtained (12.700) exceeded the minimum value as indicated in Table 4 implies that the experts reached a consensus on this particular item therefore have consensually agreed with the list of activities under this domain.

Table 4: Experts' Agreement on the list of activities grouped under Content Domain

Item 1.3			
Average responses	0.700	0.873	0.967
Fuzzy evaluation	10.50	13.10	14.50
Defuzzification value		12.700	

The next question in the evaluation survey questionnaire under the first aspect was on the experts' agreement on the list of activities grouped under technology activities. The question read: 'Do you agree with the list of activities grouped under Technology Activities as shown in the model?' This represented item 1.4 in the survey questionnaire and obtained a defuzzification value of 13.067, well beyond the minimum value of 10.5. This means that the experts had a consensual agreement on this item as indicated in Table 5.

Table 1: Experts' Agreement on the teaching activities grouped under Technology Domain

Item 1.4			
Average responses	0.727	0.900	0.987
Fuzzy evaluation	10.90	13.50	14.80
Defuzzification value		13.067	

The next item of the questionnaire, Item 1.5, was the last under the first of the two aspects of the evaluation survey questionnaire. The experts were asked: 'Do you agree with the list of activities grouped under Evaluation Activities as shown in the model?' The defuzzification value for this item once again exceeded the minimum value at 13.533 implying that the experts reached a consensual agreement on the list of activities grouped under the Evaluation Domain. Table 6 indicated the values obtained for this item.

Table Error! No text of specified style in document.: Experts' agreement on the teaching activities grouped under the Evaluation Domain

Item 1.5			
Average responses	0.780	0.933	0.993
Fuzzy evaluation	11.70	14.00	14.90
Defuzzification value		13.533	

Views on the Overall Usability and Suitability of the Model

The second aspect of the evaluation survey questionnaire focused on the overall usability and suitability of the FDML model for the teaching of arithmetic at the elementary school level. Overall, this aspect garnered 96 percent experts' consensus, exceedingly well the 75% minimum threshold value percentage. This aspect also had five (5) separate questions asked and the findings obtained are presented one-by-one in the following paragraphs. The first question under this aspect focused on the experts' agreement on the clarity of the model in guiding how mobile learning can be used for the teaching of arithmetic at the elementary school level. The experts were asked the following question: 'The model shows a clear guide on how a mobile learning can be used for the teaching of arithmetic at the elementary school level'. This was represented as Item 2.1 in the evaluation survey questionnaire. The overall defuzzification value obtained for this item was 13.167 exceeding the minimum value of 10.5 which implied that the experts had reached a consensual agreement on this particular item. Table 7 revealed the complete fuzzy results of this item.

Table 2: Experts' Agreement on the model being a clear guide on using a mobile learning application for the teaching of arithmetic at the elementary school level

Item 2.1			
Average responses	0.753	0.907	0.973
Fuzzy evaluation	11.30	13.60	14.60
Defuzzification value		13.167	

The next item of the questionnaire (Item 2.2) focused on the practicality of the teaching activities to be used in developing a model curriculum implementation. The item stated, 'It is practical to use the

teaching activities in developing a model of curriculum implementation that will guide curriculum implementers to conduct fun-driven mobile teaching as shown in this model'. Likewise, this item obtained the defuzzification value of 13.000, more than the required minimum threshold value. Table 8 indicated the entire fuzzy Delphi results of this particular item.

Table 3: The practicality of the model to be used in developing a model of curriculum implementation

Item 2.2			
Average responses	0.727	0.893	0.980
Fuzzy evaluation	10.90	13.40	14.70
Defuzzification value		13.000	

Item 2.3 represented the clarity of the model in incorporating formal classroom teaching activities with informal gaming activities. The respondents were asked the following: 'The model attachment shows clearly how formal classroom teaching activities could merge with informal gaming activities to form a holistic learning experience for students'. This item obtained the defuzzification value of 12.800 more than the required minimum value of 10.5 implying that the experts reached a consensus on the clarity of the model in incorporating formal classroom activities with informal gaming activities. Table 9 revealed the entire fuzzy Delphi results of this item.

Table 4: Clarity of the model in incorporating formal classroom activities with informal gaming activities

Item 2.3			
Average responses	0.700	0.880	0.980
Fuzzy evaluation	10.50	13.20	14.70
Defuzzification value		12.800	

Item 2.4 was on the possibility of using the model as a guide for the planning of subject unit lessons by arithmetic teachers in aiding pupils learning. The experts were asked the following: 'The model could be used to guide the planning of subject unit lessons by the teacher in facilitating students' learning'. The experts also reached a consensus on this item as the item obtained the defuzzification value of 13.167 more than the minimum value of 10.5. Table 10 revealed the entire fuzzy Delphi results of this particular item.

Table 5: Usage of the model as a guide for planning of subject unit lessons by elementary school mathematics teachers

Item 2.4			
Average responses	0.740	0.907	0.987
Fuzzy evaluation	11.10	13.60	14.80
Defuzzification value		12.800	

The last item of the evaluation survey questionnaire focused on using the model as an example of developing other curriculum models for the teaching of other subjects. The experts were asked in the following words: 'The model could be used as an example on how to develop other curriculum models for the teaching of other subjects'. This item obtained one of the highest defuzzification values of all the items at 13.500 well more than the minimum value implying experts' consensus on this particular item. Table 11 revealed all the fuzzy Delphi results for this item.

Table 6: Possibility of using the model as an example of how to develop other curriculum models for the teaching of other subjects.

Item 2.4			
Average responses	0.767	0.933	1.000
Fuzzy evaluation	11.50	14.00	15.00
Defuzzification value		13.500	

To this point, this chapter has revealed the results obtained from the evaluation phase of this research which assessed the FDML model for the teaching of arithmetic at the elementary school level. The overall results of the evaluation phase are succinctly summarized and concluded in Table 12 which consists of the average defuzzification value as well as the fuzzy evaluation of all the questionnaire items. Also, the table also displays the ranking of the items which were arrived at by comparing each activity with the rest in terms of the defuzzification value it garnered. The ranking indicated how each of the questionnaire items compared with the rest in terms of the experts' agreement. On this basis, Item 5 which asked the experts their agreement on the list of activities grouped under Evaluation Activities as shown in the model was ranked the highest of all the items followed by Item 1 and Item 10. On the opposite end of the spectrum, Item 3 which asked the experts their agreement on the list of activities grouped under Content Activities as shown in the model ranked the lowest of all the items of the questionnaire followed by Item 2.

Table 7: Defuzzification and Average Fuzzy Numbers of all the Questionnaire Items

Item	Value Score		Ranking
	<i>Fuzzy Evaluation</i>	<i>Average of Fuzzy Number</i>	
1	13.500	0.900	2
2	12.700	0.847	9
3	12.700	0.847	10
4	13.067	0.871	6
5	13.533	0.902	1
6	13.167	0.878	4
7	13.000	0.867	7
8	12.800	0.853	8
9	13.167	0.878	5
10	13.500	0.900	3

Conclusion

The study aimed at the evaluation of the FDML model for the teaching of arithmetic at the elementary school level based on the following set of questions:

- What is the experts' agreement on the suitability and usability of the mobile learning teaching activities proposed in the FDML model for the teaching of arithmetic at the elementary level?
- What is the experts' agreement on the classification of the FDML model teaching activities based on the four domains (introductory activities, contents activities, technology-based activities, and evaluation activities) proposed in the FDML model of teaching mathematics at the elementary level?

A group of fifteen (15) experts were selected and presented with questionnaires consisting of two separate sections. Also, the questionnaires were divided into two major sections: section one focused on getting the background information on the experts and the second section was dedicated to getting the experts' views on the model. The fuzzy Delphi method was employed for the analysis of the data collected via the questionnaires. Findings revealed that based on the threshold value' (as presented in Table 2) and the defuzzification value (as presented in Table 3), the experts of this phase had a

unanimous consensual agreement to all the questionnaire items consisted in the questionnaire. Impliedly, this meant that all the experts involved in this evaluation phase had a consensual agreement on the suitability and applicability of the model to be employed in guiding mathematics elementary school level teachers to implement the FDML model as learning support for the teaching of mathematics at the elementary school level.

References

- Abouelnaga, H. M., Metwally, A. B., Mazouz, L. A., Abouelmagd, H., Alsmadi, S., Aljamaeen, R., ... & Hamad, A. L. (2019). A survey on educational technology in Saudi Arabia. *Int. J. Appl. Eng. Res.*, 14(22), 4149-4160.
- Alqarni, A. A. (2015). Educational technology in Saudi Arabia: A historical overview. *International Journal of Education, Learning and Development*, 3(8), 62-69.
- Al-Emran, M., Mezhyuev, V., & Kamaludin, A. (2018). Technology Acceptance Model in M-learning context: A systematic review. *Computers & Education*, 125, 389-412.
- ALzahrani, S. (2017). *Saudi Mathematics Teachers' Understanding and Practices of Formative Assessment in Elementary Schools*. ProQuest LLC.
- Alyahya, D. M., & Alotaibi, A. M. (2019). Computational thinking skills and its impact on TIMSS achievement: An Instructional Design Approach. *Issues and Trends in Learning Technologies*, 7(1).
- Aldahmash, A. H., Alamri, N. M., & Aljallal, M. A. (2019). Saudi Arabian science and mathematics teachers' attitudes toward integrating STEM in teaching before and after participating in a professional development program. *Cogent Education*, 6(1), 1580852.
- Adler, M., & Ziglio, E. (1996). *Gazing into the oracle: The Delphi method and its application to social policy and public health*. Jessica Kingsley Publishers.
- Al-Fahad, F. N. (2009). Students' attitudes and perceptions towards the effectiveness of mobile learning in King Saud University, Saudi Arabia. *Online Submission*, 8(2).
- Alharbi, S., & Drew, S. (2014). Using the technology acceptance model in understanding academics' behavioural intention to use learning management systems. *International Journal of Advanced Computer Science and Applications*, 5(1), 143-155.
- Alsuwidan, S. I. (2018). The Teacher Perspective on Integrating Technology into Their Early Childhood Classrooms in Saudi Arabia. *ProQuest LLC*.
- Chan, K. K. W., & Kong, S. C. (2011). *Process Writing: an online collaborative writing environment for primary school students*.
- Chang, K.-E., Wu, L.-J., Weng, S.-E., & Sung, Y.-T. (2012). Embedding game-based problem-solving phase into problem-posing system for mathematics learning. *Computers & Education*, 58(2), 775-786.
- Delbecq, A. L., Van de Ven, A. H., & Gustafson, D. H. (1975). *Group techniques for program planning: A guide to nominal group and Delphi processes*. Scott, Foresman,.
- Ellis, K., Stam, K., & Lizardi, R. (2019). *Enhancing Community and Creating Unity Using a Mobile Application* (Doctoral dissertation, SUNY Polytechnic Institute).
- Gustafson, D. H., Delbecq, A. L., Hansen, M., & Myers, R. F. (1975). Design of a health policy research and development system for Wisconsin. *Inquiry*, 12(3), 251-262.
- Huang, Y. L., Chang, D. F., & Wu, B. (2017). Mobile game-based learning with a Mobile app: Motivational effects and learning performance. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, 21(6), 963-970.
- Jusoh, N., Salam, R. A., & Sayuti, M. N. S. M. (2012). Color Image Enhancement using Contrast Stretching on a Mobile Device. *Faculty of Science and Technology, Universiti Sains Islam Malaysia, Negeri Sembilan*, 1(3).
- Ke, F. (2008a). Alternative goal structures for computer game-based learning. *International Journal of Computer-Supported Collaborative Learning*, 3(4), 429.
- Ke, F. (2008b). Computer games application within alternative classroom goal structures: cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development*, 56(5-6), 539-556.
- Mansour Alabdulaziz, P., & Higgins, S. (2017). Understanding Technology Use and Constructivist

- Strategies when Addressing Saudi Primary Students' Mathematics Difficulties.
- Mohamad, S. N. A., Embi, M. A., & Nordin, N. M. (2015). Are students ready to adopt E-Portfolio? Social science and humanities context. *Asian Social Science*, 11(13), 269.
- Mason, J., Burton, L., & Stacey, K. (2011). *Thinking mathematically*. Pearson Higher Ed.
- Morsanyi, K., Prado, J., & Richland, L. E. (2018). The role of reasoning in mathematical thinking. *Thinking & Reasoning*, 24(2), 129–137.
- Naik, N. (2014, October). A comparative evaluation of game-based learning: Digital or non-digital games?. In *European Conference on Games Based Learning* (Vol. 2, p. 437). Academic Conferences International Limited.
- Ozuorcun, N. C., & Tabak, F. (2012). Is m-learning versus e-learning or are they supporting each other?. *Procedia-Social and Behavioral Sciences*, 46, 299-305.
- Park, Y. (2011). A pedagogical framework for mobile learning: Categorizing educational applications of mobile technologies into four types. *International Review of Research in Open and Distributed Learning*, 12(2), 78-102.
- Prensky, M. (2001). Fun, play and games: What makes games engaging. *Digital Game-Based Learning*, 5(1), 5–31.
- Saido, G. A. M., Siraj, S., Dewitt, D., & Al-Amedy, O. S. (2018). Development of an instructional model for higher order thinking in science among secondary school students:
- Squire, K., & Dikkers, S. (2012). Amplifications of learning: Use of mobile media devices among youth. *Convergence*, 18(4), 445–464.
- Taylor, R. E., & Judd, L. L. (1989). Delphi method applied to tourism. *Delphi Method Applied to Tourism*, 95-98.
- Witkin, B. R., Altschuld, J. W., & Altschuld, J. (1995). *Planning and conducting needs assessments: A practical guide*. London: Sage. a fuzzy Delphi approach. *International Journal of Science Education*, 40(8), 847-866.
- Yelland, N. (2015). Young children as multimodal learners in the information age. In *Young children and families in the information age* (pp. 151–163). Springer.