Journal of Digital Art Engineering & Multimedia Vol.9, No.1, March (2022), pp.13-23
ISSN 2508-9099(p) 2672-1198(e) *http://dx.doi.org/10.29056/jdaem.2022.03.02*

A Study on the Potential Integration of AR-based Games in Learning Information System Documentation

Minkyu Choi[1], JungYoon Kim[2]*

Abstract

Various technologies have been widely adopted to enhance learning in different courses. These include both hardware-related (e.g., PCs, laptops, projectors, tablets, smartphones, televisions, etc.) and software-related (e.g., QR codes, the Web, social media sites, slides, videos, sounds, narrations, games, etc.) technologies. This paper deals with the potential integration of AR-based games to supplement the learning of information system (IS) documentation. The design is structured into five mini-games with contents that include the understanding of DFDs, ERDs, and flowcharting techniques comprised of system, program, and document flowcharting. The five mini-games are the IS symbol crush game, the IS symbol identification game, the IS symbol classification game, the IS picture guessing game, and the IS process solving game. The quality of service (QoS) of the AR-based games in learning IS documentation can be measured through its mobility/portability, effectiveness, efficiency, satisfaction, and context coverage.

Keyword : Augmented Reality (AR), Information systems, Learning, Data Flow Diagram (DFD), Entity Relationship Diagram (ERD), Flowchart, Games

1. Introduction

Learning nowadays is not limited to the four corners of the classroom. Innovative learning methods, techniques, and strategies have been widely implemented in order to provide an enhanced, collaborative, and interactive learning environment. In this regard, technologies have been adopted by educational institutions to supplement and enhance the learning instructions to allow for greater learning stimulations. These can include both hardware-related and software-related technologies. The hardware-related technologies may include personal computers (PCs), laptops, smartphones, personal digital assistants (PDAs), tablets, radios, televisions, projectors, etc. On the other hand, software-related technologies may include quick response (QR) codes, the Web, social media sites (e.g., Facebook, YouTube, SlideShare, etc.), multimedia files, videos, narrations, sounds, games, etc. Brown et al. [1] has examined the

1 Graduate School of Game, Gachon University, Seongnam-si, Gyeonggi-do, Republic of Korea [Research professor]
e-mail: minkyu.mk@gachon.ac.kr
2 Graduate School of Game, Gachon University, Seongnam-si, Gyeonggi-do, Republic of Korea [Professor]
e-mail: kjyoon@gachon.ac.kr (Corresponding author)
* This Paper was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. NRF-2019R1G1A1100341)

Received(January 15, 2022), Review Result(1st: January 31, 2022), Accepted(March 17, 2022), Published(March 31, 2022)

re-imagination of the educational culture that promotes new approaches to learning that is mediated by technology. The study has demonstrated that learning environments being mediated by technology (i.e., the re-imagined pedagogical design) have shifted towards a more engaging and supportive learning experience that can be potentially applied in higher educational contexts.

Learning of Information systems (IS) documentation is an essential requirement not only for business students but also for information technology students who are aspiring to become system analysts in the future [2][3]. Learning of IS documentation can be done through reading, listening to lectures, and watching tutorial videos or multimedia presentations. This learning method has been proven effective, however, for some students, the learning can be considered as very traditional and boring as interactivity and collaboration can be limited. In this regard, innovation in teaching strategies and its convergence with information and communication technology (ICT) can be essentially necessary.

Digital games in learning is an innovative method to enhance learning allowing for collaboration and interactivity in the learning environment [4-6]. Games in learning can be integrated in almost all learning levels, that is, from young children, to teenagers, to university students, and even for adults. In addition, games can be included in learning various courses that may include science, mathematics, language, business, etc. In some educational institutions, subject matters have been gamified in order to enhance the learning environment. Gamification enhances the lectures on particular subjects (e.g., programming, business processes, etc.) creating an activity-oriented learning environment similar to experiences of playing games to further the learner's motivation and engagement [7-10].

In addition, the proliferation of augmented reality (AR) in games has added innovative features that can be beneficial for integrating games into learning. For instance, the study of Wang and Khambari [11] focused on learning English sentences and has utilized the activity theory in structuring a game-based AR learning model (GBARLM). The results of the study had a positive effect on learning English as it enhanced learning interactions. The GBARLM environment has enabled collaborative learning. The study of T. Laine [12] stated that AR-based games have shown significant affordances when integrated into learning. The study has explored the research landscape of educational mobile AR games (EMARGs) and presented 13 guidelines for future EMARG developers. Learning theories must be understood on how mobile AR games can be best applied.

This paper has analyzed the potential integration of AR technology in digital gaming which is designed to supplement the learning of business IS documentation. It aims to implement IS documentation contents that include data flow diagrams (DFD), entity relationship diagrams (ERD), document flowchart, program flowchart, and system flowchart. The design of its structure is comprised

of five mini-games that integrate AR technology to allow an enhanced real-world learning environment.

The rest of this paper is organized as follows: Section 2 discuss the AR-based game contents; the discussion on the AR-based game structure is outlined in Section 3; the discussion on measuring the quality of the suggested AR-based game is presented in Section 4; and the concluding remarks and future research directions were presented in Section 5.

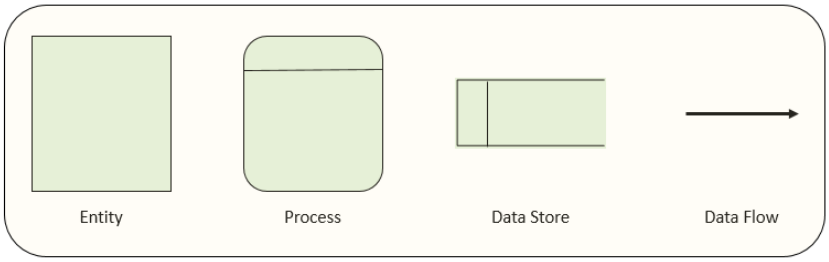
2. Proposed AR-based Game Contents

This section provides a discussion on the contents of the proposed AR-based games to supplement the learning of IS documentation. The contents will include data flow diagrams (DFDs), entity relationship diagrams (ERDs), and flowcharting (i.e., program flowchart, system flowchart, and document flowchart).

2.1 Data Flow Diagram

Data flow diagrams (DFDs) refers to the graphical representation of a business IS showing how it stores, process, and transforms data to become meaningful information [13][14]. They are visual models that can only show how data moves through the IS (i.e., shows what a particular business IS does) and not the detailed program logic (i.e., the detailed steps the data has taken). In this category of IS documentation, a process receives input data, performs the necessary process, and produces the desired output that can be represented in different forms.

DFDs use different symbols in representing the processes, data flows, data stores, and entities as depicted in [Fig. 1]. These symbols will be integrated into the AR-based game designed to supplement the learning of IS documentation (i.e., particularly with DFDs). The first image in [Fig. 1] depicts the entity symbol that can either be an external data source (i.e., supplies data to the IS) or a data destination (i.e., also called the sink which receives data from the IS). The entity name is written inside the symbol. This will show the IS boundaries and how it interfaces with the outside world. The second symbol depicts the process that receives input data, performs the particular process (i.e., usually indicated by the name written in the symbol), and produces output. They define the business rules that transform the received data (i.e., input) into the required results (i.e., output). The third symbol indicates a data store (i.e., usually a file) that is used to represent data that the IS stores for future usage. Finally, the last symbol indicates a data flow that signifies the path in moving data between parts of the IS.

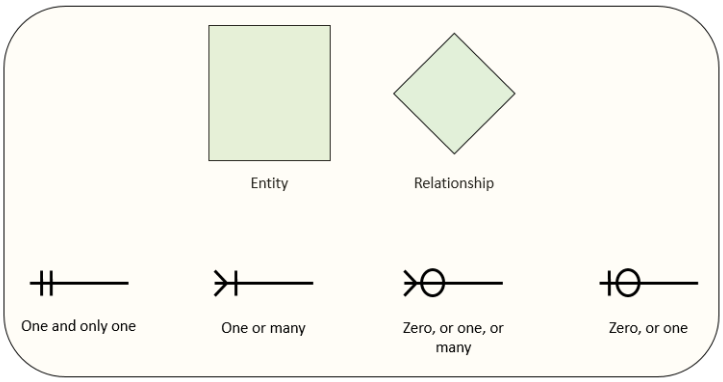


[Fig. 1] Different DFD Symbols

2.2 Entity Relationship Diagram

Entity Relationship Diagrams (ERDs) refer to a graphical representation that shows the relationship among data elements of an IS [13][15]. They are visual models that indicate the logical relationships as well as the interactions between IS entities. Unlike DFDs, the ERDs are used to indicate relationships and not the data flows. ERD is also a valuable tool in modeling the IS database.

ERDs use a rectangle symbol for representing entities and diamond shapes represent the relationships among the entities as depicted in [Fig. 2]. The relationships (i.e., cardinality) between two entities can include “one-to-one”, “one-to-many or vice versa”, and “many-to-many”. These cardinalities can be represented by four different symbols of “one and only one”, “one or many”, “zero, or one, or many”, and “zero, or one” which are placed at both ends of the connectors.

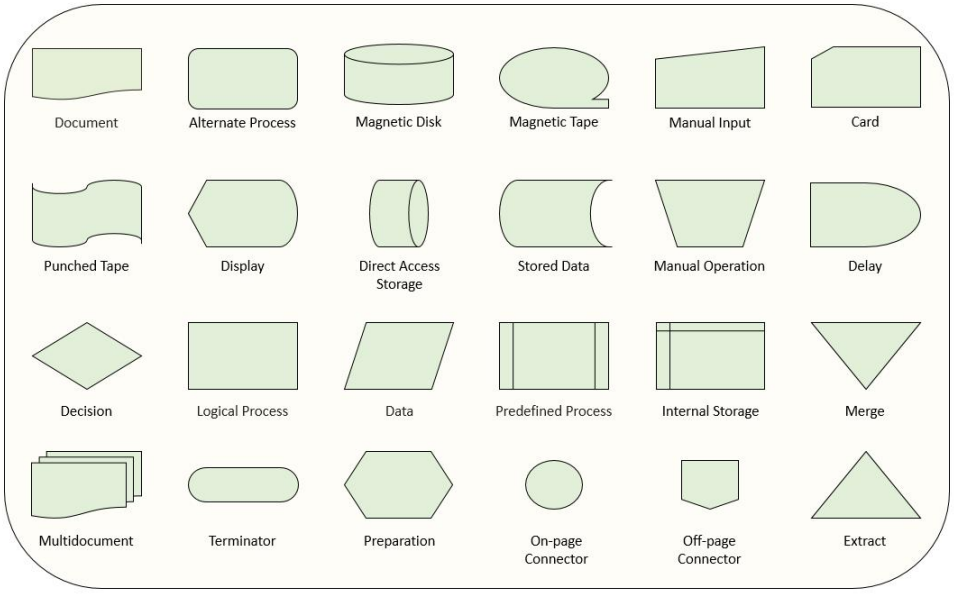


[Fig. 2] Different ERD Symbols

2.3 Flowcharts

The flowchart refers to a graphical representation that can describe the business logic or the

operational steps of an IS [14][15]. They can be categorized into a document, system, and program flowcharts.



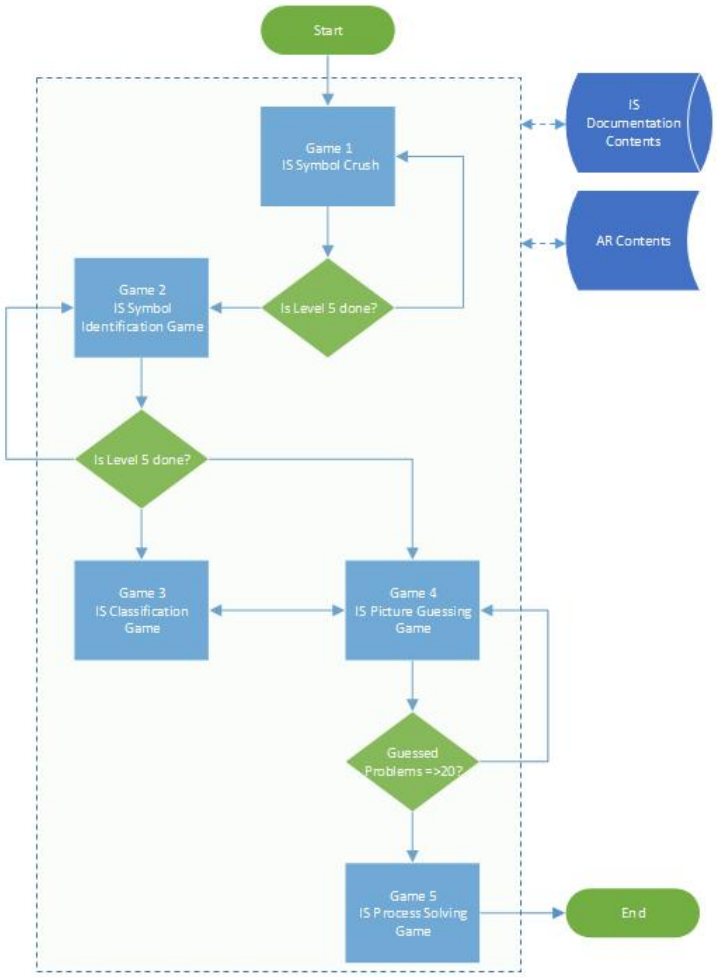
[Fig. 3] Flowchart Symbols

The document flowchart signifies the flow of documents and information between the different departments in a business institution or an organization. That is, document flowcharts can show how documents are moved from one department or entity going to another. On the other hand, the system flowchart signifies the key elements, input data sources, and process results (i.e., output) of an IS. Generally, system flowcharts start with the identification of the different inputs or data that enters into the IS. Then, this input will be processed and the results will be the transformed information that can be meaningful for the next processes or to its other destinations (e.g., entities). The output can also be moved into data storage for later usage. Finally, the program flowchart provides a graphical representation of the processing logic that is indicated in the system flowchart. The different symbols used in flowcharting that will be integrated into the proposed AR-based games are depicted in [Fig. 3].

3. Proposed AR-based Game Structure

The AR-based game must be provided to the learners after they have received a prior lecture or learning of IS documentation. The structure of the AR-based game for learning IS documentation is

comprised of five mini-games that go one after the other as depicted in [Fig. 4]. The five mini-games include the IS Symbol Crush Game, the IS Symbol Identification Game, the IS Symbol Classification Game, the IS Picture Guessing Game, and the IS Process Solving Game.



[Fig. 4] Properties Measuring the Quality of the Design of AR-based Games

The player (i.e., IS documentation learner) starts with playing the first mini-game IS Symbol Crush game which is consists of 10 levels with varying difficulties. In this mini-game, a screen with a 10x8 grid (i.e., 10 rows by 8 columns) of different IS documentation symbols (i.e., comprised of three categories of DFD, ERD, and flowcharting symbols) is presented to the player. At least three similar symbols must be matched vertically, horizontally, or forming a T-shape by the player. The matched symbols then pop out of the screen and its name and purpose of use flash on the screen to allow IS

documentation learning for the player. The score also increments that depend on the number of symbols being matched. Then, random IS symbols move down to replace the matched set of IS symbols. In addition, an AR-generated symbol may appear randomly to replace a symbol in a random grid location that doubles the score when matched with other existing similar symbols. A required score must be reached in order to proceed with the next level. The second game will be unlocked once the player met the required score for level 5 (i.e., finishing level 5). The player can then jump to the second mini-game or can continue playing through level 10 and familiarize more of the IS documentation symbols. In this mini-game, the players will be able to familiarize themselves with the different IS documentation symbols and their specific purpose.

The second mini-game is comprised of 10 levels of flashing IS documentation symbols for the player to identify its name and category (i.e., DFD, ERD, or Flowcharting). In this mini-game, random IS documentation symbols flashes on the player's screen to identify within a pre-set time (i.e., the time allotted per item changes as the game progresses). The player must correctly identify 10 successive random IS documentation symbols without committing any mistake in order to proceed with the next level. Correct identification of the name and category of a symbol increment the score and a "congratulation" message flashes on the player's screen. On the other hand, when a mistake is committed, a "wrong answer" message flashes on the players' screen, and a list of possible answers will be displayed for the player to choose from. The player then will be allowed to choose the correct answer in two tries. Whenever the player cannot provide the correct answer within the allowable time and number of tries, the message "incorrect identification" will be displayed together with the correct name and category for the unidentified symbol. Finishing level 5 of this mini-game unlocks both the IS Classification game and the IS Picture Guessing game.

In addition, random AR-generated symbols may appear and correct identification of its name and category doubles the player's score. This mini-game supplements the IS documentation learning as the players try to familiarize the different names and uses of the various symbols that they have to identify. This is also useful in order to recall the learning received by the players from the previous mini-game.

The third mini-game consists of 10 levels of IS documentation symbols that were falling randomly down from the top of the player's screen. The players must navigate the IS documentation symbols into their correct category as they fall down on the screen. That is, the playing screen is divided into three different columns that correspond to three categories of IS documentation, namely, DFD, ERD, and Flowcharting. Thus, the players will guide the symbols either to the left column (i.e., DFD category), in the middle column (i.e., ERD category), or to the right column (i.e., Flowcharting category). Every

correct player navigation means the player has categorized the symbol correctly and increments his/her score. The column will not accept the symbol whenever the player has navigated them into the wrong category. Time pressure is included in order to provide difficulty variation as the game progresses. In addition, randomly generated AR-based IS documentation symbols may appear and scores double once they are navigated correctly by the player to its corresponding category.

The player has the option to switch and play the fourth mini-game named the IS Picture Guessing game as they are unlocked together after finishing level 5 of the second mini-game. However, at least five levels on this mini-game must be completed in order to play the fifth and last mini-game. This mini-game will improve the player's ability in classifying the different IS documentation symbols based on whether they belong to DFD, ERD, or Flowcharting symbols.

The fourth mini-game is called the IS Picture Guessing game and consists of 100 sets of four-picture guessing items for the player. That is, the player will be given a set of four pictures (i.e., related to Business Management, Accounting, and Organizational Information Systems) to guess and identify the correct single word that best describes them. Hints will be given at the beginning items and the difficulty becomes higher as the mini-game continues. Correct guesses provide the player with corresponding scores and additional information regarding the identified pictures is given as bonus learning information. In addition, AR-based pictures may appear as bonus guessing items for the players with a double score reward. The final mini-game will be unlocked after finishing 5 levels of the third mini-game and after identifying 20 items in this mini-game. This mini-game will supplement the player's understanding of the different subjects and terms being used in managing Information Systems.

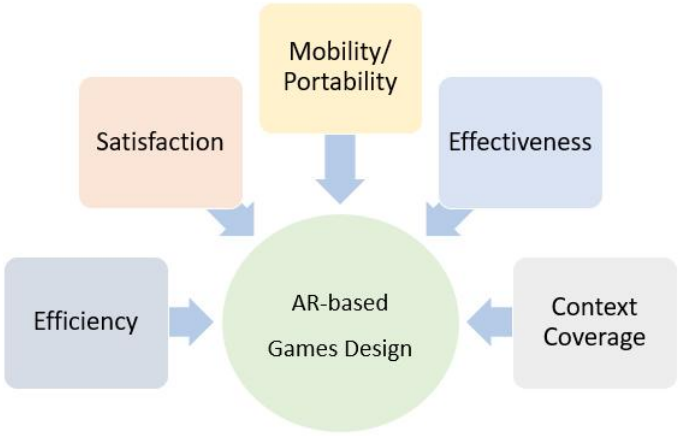
The last mini-game is consists of 100 situational IS process-solving problems that the player must analyze and document. That is, case studies of IS transactions will be given and the players must use proper IS symbols in constructing either the DFD, ERD, or Flowchart (i.e., based on the required IS documentation). Corresponding scores will be given to the player for the correct IS documentation and additional information are given as learning supplements. The IS documentation problems will be consist of different business system processes that will include but are not limited to Enterprise Computing, Transaction Processing (TP), Business Support, Knowledge Management, and User Productivity. The flowcharting problems may include transaction cycles such as the Revenue, Expenditure, and Conversion cycles. Difficulty varies as the game progresses (i.e., from simple to complex IS documentation problems. In addition, AR-based objects and hints will be flashing randomly that can augment the player's learning as well as increase his/her scores.

4. Discussions

AR technologies can greatly impact the gaming industry (i.e., games for entertainment or educational games) as it enables an enhanced and interactive real physical learning environment. This technology stimulates the learner's interactive experience of the real-world learning environment by augmenting or providing technology-generated perceptual objects or information or objects.

The Quality of Service (QoS) of the AR-based games for learning IS documentation is necessarily important in order to measure its efficiency and to validate its potential integration. Five major properties based on the ISO/IEC 25010: 2011 depicted in [Fig. 5] have been identified in measuring the quality of the designed AR-based games which are summarized as follows:

- *Mobility/Portability* refers to the AR-based game design's capability in delivering continuous game interactive activities to the learners of IS documentation while allowing them to freely roam around the learning environment, hence, allowing for learning remotely. It allows self-learning and self-guided activities which are brought by AR technologies and portability of the learners' mobile devices.
- *Effectiveness* refers to the measure of the quality of the AR-based games in relation to the accuracy and completeness with which the IS documentation learners have achieved their objectives.
- *Efficiency* refers to the set of attributes indicating the performance level of AR-based games designed to supplement the learning of IS documentation. This property includes the timely delivery of learning activities (i.e., game challenges) as the game progresses.
- *Satisfaction* refers to the measure to which the required learning needs are satisfied with the game challenges specified and delivered by the AR-based games for learning IS documentation. It also consist of the user's response to interaction and engagement with the learning activities (i.e., game challenges), and includes attitudes towards the usage on the features of the designed game. In addition, the game design must be user-friendly, that is, it is easy to learn, navigate, and play. The settings, functionalities, and graphics must be properly arranged for easy navigation and playing.
- *Context* coverage refers to the measure to which the AR-based games can be integrated into learning IS documentation with mobility/portability, effectiveness, efficiency, and satisfaction in its specified contexts. This property includes context completeness (i.e., must include all of the specified learning contents in the course objectives) and flexibility (i.e., the game design can be flexible for additional learning contents, additional learners, and diversity of learning environments).



[Fig. 5] Properties Measuring the Quality of the Design of AR-based Games

The proliferation of the implementation of AR in educational gamification has allowed for an enhanced, collaborative, interactive, and engaging learning of IS documentation. In addition, gamification provides more motivation in learning and allows the learners to have greater focus.

5. Conclusion

The integration of digital gaming into education has exhibited positive effects on learning as the environment becomes more interactive and engaging. This paper deals with the design of AR-based games to supplement the learning of IS documentation such as DFDs, ERDs, and Flowcharting. The proposed AR-based game is structured into five mini-games that integrate IS documentation contents. The design is evaluated based on five properties of mobility/portability, effectiveness, efficiency, satisfaction, and context coverage.

In the future, the detailed design on the structure of each proposed AR-based mini-games in this study will be presented. Also, its evaluation results as compared with other existing AR-based games will be analyzed and presented.

References

[1] K. Brown, V. Larionova, N. Stepanova, V. Lally, "Re-imagining the Pedagogical Paradigm Within a Technology Mediated Learning Environment", Open Education Studies, vol. 1, no. 1, November 2019, pp. 138-145, doi: 10.1515/edu-2019-0009.

[2] J. A. O'brien, C. A. VanLengen, "Evaluating information Systems documentation technique", Journal of Information Systems Education, vol. 4, no. 3, 1992, pp. 32-41.

[3] F. A. Laguda, "Importance of documentation to system analysis", slideshare.net, www.slideshare.net/FemiAkin Laguda/importance-of-documentation-to-system-analysis, (Accessed September 24, 2021).

[4] L. A. Annetta, "Video Games in Education: Why They Should Be Used and How They Are Being Used", Theory into Practice, vol. 47, no. 3, October 2009, pp. 229-239, doi: 10.1080/00405840802153940.

[5] S. Liu, J. Kang, "An Overview of Game Based Learning: Motivations and Authentic Learning Experience", Texas Education Review, vol. 2, no. 2, 2014, pp. 157-162.

[6] Entertainment Software Association, "Games: Improving Education", paperzz.com, www.paperzz.com/doc/7199 849/games--improving-education---entertainment-software-assoc, (Accessed September 24, 2021).

[7] W. H. Y. Huang, D. Soman, "A Practitioner's Guide to Gamification of Education", academia.edu, www.academia.edu/33219783/A_Practitioners_Guide_To_Gamification_Of_Education, (Accessed May 24, 2021).

[8] A. Baker, C. Dede, J. Evans, "The 8 Essentials for Mobile Learning Success in Education", Qualcomm Wireless Research, CA, USA, November 2014, [Online]. Available: www.qualcomm.com/media/documents/file s/the-8-essentials-for-mobile-learning-success-in-education.pdf, (Accessed May 24, 2021).

[9] D. Parsons, K. Petrova, H. Ryu, "Designing Mobile Games for Engagement and Learning", The 7th International Conference on Information Technology and Applications, November 21-24, 2011, Sydney, NSW, Australia, pp. 261-266.

[10] C. Aldrich, Learning Online with Games, Simulations and Virtual Worlds: Strategies for Online Instruction, California: USA, John Wiley & Sons, Inc., 2009.

[11] D. Wang, M. N. M. Khambari, "The application of a game-based AR learning model in English sentence learning", Malaysian Online Journal of Educational Technology, vol. 8, no. 1, January 2020, pp. 63-71, doi: 10.17220/mojet.2020.01.005.

[12] T. H. Laine, "Mobile Educational Augmented Reality Games: A Systematic Literature Review and Two Case Studies", Computers, vol. 7, no. 1, March 2018, pp. 19, doi: 10.3390/computers7010019.

[13] J. A. Hall, "Accounting Information Systems", 7th Edition, Ohio: USA, Cengage Learning, 2011.

[14] N. A. Bagranoff, M. G. Simkin, C. S. Norman, "Core Concepts of Accounting Information Systems", 11th Edition, New Jersey: USA, John Willey & Sons, Inc., 2010.

[15] M. B. Romney, P. J. Steinbart, "Accounting Information System", 14th Edition, New Jersey: USA, Pearson Education, Inc., 2003.