Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 4 (2024)

Development of a Mobile Based Game with Image Recognition for Preschoolers

Ellen Flores Mangaoang[1], Thelma Domingo Palaoag[2]

[1] *College of Information and Computer Science, University of the Cordilleras, Baguio City, Philippines*

[2] *College of Information and Computer Science, University of the Cordilleras, Baguio City, Philippines*

Abstract:- Learning is not only confined in the classroom but also with the use of technology through the development of mobile games and learning management systems. Preschoolers are very active in the use of the technology by using their mobile devices to play games which are often not designed for their age and not educational. Preschoolers prefer fun and engaging learning. This goal of the study is to design and develop a mobile application which aids in the learning experience of preschool students by providing an interactive game with the inclusion of image recognition. Incorporating image recognition technology will aid preschoolers in their ability to learn and identify various objects. This study was beneficial to preschoolers as this helped them in understanding the lessons in a fun and interactive manner. This study uses a descriptive-developmental research method with the ADDIE model being utilized in the development of the mobile application. The model for the image recognition part of the application was developed using Google's Teachable Machine and a TensorFlow lite model was deployed in the application. The usability of the application was determined using the USE tool. The developed mobile based game presents a unique learning experience to preschoolers as it provides learning in a fun way and is suitable for preschoolers.

Keywords*: Googles' Teachable Machine, image recognition, mobile based game, preschoolers.*

1. Introduction

One of the most important roles of young children love playing. Preschool is a time when children begin to assert their independence and develop unique ways of thinking. Their natural curiosity fuels a passion for discovery [1]. The formative years of early childhood are indispensable for acquiring the knowledge, skills, and values that will serve as a child's lifelong compass. This period is marked by rapid development in all areas, including intellect, emotions, and social interactions [2].

Early childhood is a sensitive time, according to many experts, and highly crucial to a child's development. Parents and other adults surrounding the child's environment will stimulate the child, leaving a powerful and enduring imprint. Even a small misstep in the stimulation process will have detrimental long-term effects that are challenging to reverse. The most vulnerable time is comparable to when a blacksmith should forge heated iron. When iron is to be formed, the smiths must be exceedingly knowledgeable. Iron is difficult to shape and mold if it is forged too early. On the other side, the iron will be ruined if the forging is done too late. So, the best time for a child to get a proper educational evaluation is at an early age [3].

For the past forty years, new advancements in game-based learning (GBL) studies have been available, but their applicability and use in the classroom still pose a significant issue [4]. Many studies have raised concerns about the detrimental effects of excessive digital game-play in early childhood, including potential contributions to physical inactivity and impaired psychomotor skill acquisition [5].

While computers may have technical advantages, the optimal device for preschoolers' game-based learning is the mobile device, which offers a more engaging and effective learning experience [6]. Digital games used as instructional tools can create positive social environments and reduce emotional distress in the classroom. A

crucial next step is the development of digital game-based learning platforms designed with preschoolers in mind. These platforms should be built upon a strong foundation of early childhood education theory [7].

Digital game-based learning (DGBL) may be a solution for low performing students as games help in the understanding of the subject matter as well as retention [8]. Compared to traditional methods, educational computer games led to notably better academic performance and a more positive attitude towards science. As a result, game-based learning in the classroom can help kids become more creative as it aids in fostering motivation and academic success. In addition to its potential for education and enjoyment, a well-designed game-based learning can encourage communication between peers [9]. To fully understand a concept, students must possess a scientific comprehension of its core ideas and be able to utilize this knowledge in practical contexts. Despite all the advantages of the game-based approach to chemistry instruction that have been emphasized, many teachers still find it difficult to adopt particularly in less developed countries. For instance, despite games' proven effectiveness in helping students learn, our earlier study [10] found that teachers rarely include them into their regular teaching activities. To ensure that every student succeeds in their education, teachers should routinely employ DGBL and technology in the classroom. Playing games to put what they have learned in class into practice can also help students become more comfortable with their academic material and reduce problems like math anxiety [11].

Another technology to look into is Artificial intelligence (AI). AI technology can improve educational outcomes by providing tools to assist teachers, streamline instruction, and offer customized learning experiences for each student [12]. AI-based educational systems greatly enhance instructional methods. Boring theoretical concepts can often be more enjoyable [13]. By leveraging AI and Machine Learning (ML) technologies, teachers can create a more stimulating and enjoyable learning environment for young children, ultimately improving their educational outcomes [14]. ML has quickly emerged as the core technology for a variety of applications, and both its value and its application fields are expanding quickly. Despite this, research on computing education has mostly ignored machine learning, especially for young children [15]. Some of the use of machine learning applications has been in detecting emotions [16], detecting achievements [17], and vocabulary learning applications [18]. With machine learning, students can receive assistance in a way they can work on their weak areas in a more effective manner [19].

In the Philippines, 3 to 4 - year old kids are not mandated to attend preschool. However, they should be attending preschool to stimulate their brains and prepare themselves for mandatory kindergarten [20]. This research focuses on designing and developing a mobile-based game incorporating image recognition technology specifically for preschool-aged children. Through this study, the preschoolers will have a supplementary tool in learning. The preschoolers will be able to understand the alphabet, colors, animals, shapes, and fruits through an interactive and fun way. The USE tool was utilized to determine the usability of the application in terms of Usefulness, Ease of Use, Ease of Learning, and Satisfaction.

2. Methods and Methodology

A descriptive and developmental approach was employed in this study. Data collection and the application’s usability were assessed using descriptive methods. The researcher utilized the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model as presented in Figure 1. The ADDIE model helps educators improve their teaching competencies in the design of better instructional materials [21]. This is an instructional model for technology-based teaching.

Figure 1. The ADDIE Model

2.1 Analysis

The researcher gathered information from preschool teachers about what lessons and learning materials they are utilizing for their classes as well as the problems encountered in the delivery of the learning materials.

2.2 Design

In this phase, the learning objectives, content, subject matter, presentation, and resources were looked into.

2.3 Development

The researcher used Android Studio for developing creative user interfaces, Java for the programming language, Firebase for the database, and XML for the design. In applying image recognition, image classification using Google's Teachable Machine (GTM) was utilized in the training of the model. GTM is an online platform that simplifies machine learning model creation for all users [22]. GTM lets users build quick and efficient browser-based algorithms that can: recognize patterns in pictures, recognize patterns in the audio and recognize any motions or poses [23]. The data sets were selected from Animals-10 and Fruits and Vegetable Image Recognition Dataset. Other images were downloaded through Image Downloader. Initially, there are twenty classes used in the model training where 85% were used to train the model as training samples and 15% for test samples. The model was trained with epochs = 50, batch size=16 and learning rate=0.001. After training the model, a TensorFlow lite model was exported and integrated in the application. As an open-source platform, TensorFlow offers a rich ecosystem of tools, libraries, and community support for building a wide range of machine learning applications. Its core strength lies in efficient computation for deep neural networks [24].

2.4 Implementation

The system was presented to the preschool teachers and parents for comments, suggestions and further improvement.

2.5 Evaluation

The purpose of the evaluation was to verify if the application could serve as an additional learning tool for preschool children. There are twenty-one respondents which comprise sixteen teachers and five parents who evaluated the level of usability of the system using the USE tool. The USE's dependability was comparable to that of other usability surveys. Additionally, the USE tool was sensitive in capturing the variance in usability, learning curve, and satisfaction amongst various items [25]. The usability of the system was interpreted using a 7-point Likert Scale.

3. Results and Discussion

The researcher found out that teachers have their own teaching guide in conducting their class. Activities such as coloring, identifying shapes, basic numbers, alphabets and basic writing are given to students. In the class, the

teacher motivates students by giving examples and presents the subject matter through visual illustrations such as videos, flash cards, work books and visual aids.

3.1 Development of the Mobile Based Game with Image Recognition for Preschoolers

DGBL studies have proposed different frameworks for game – based learning. In one study, HEXA-GBL is a comprehensive six-stage process for creating effective game-based learning experiences. It involves identifying learning goals, understanding learner needs, designing game mechanics, assessing learning outcomes, and evaluating the overall gaming experience [26].

In another study, the proposed framework for STEM digital game-based learning consists of three core components: digital game development, user experience, and learning outcomes. Although the model shows promise in comparison to existing market offerings, it necessitates a structured development process [27].

Tankui and Keong [28] adapted the Input – Process – Outcome Game Model and proposed a framework based on learning theories and the "open-world" components of Minecraft. The framework can be used as reference when implementing DGBL to create a virtual learning environment with the goal of raising students' proficiency in fractions.

This study's framework was adapted from the framework of the study Design of Mobile Game-Based Learning Application for Children with Dyslexia [29] as shown in figure 2. Unlike other frameworks, this framework was designed for a specific type of learner and their needs. To effectively create the mobile application, it is crucial to incorporate insights into learner profiles, curricular goals, game-based learning principles, and feedback mechanisms.

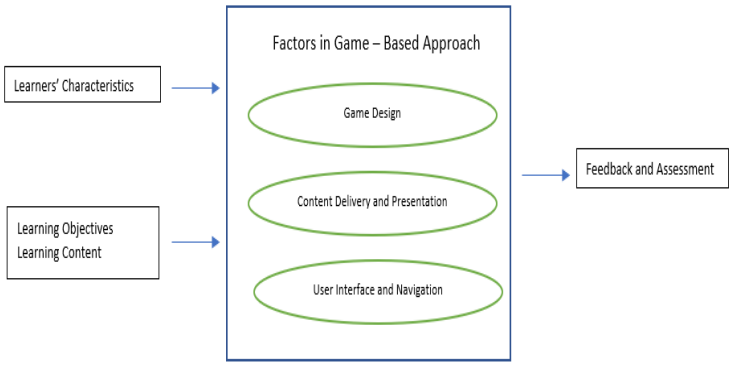

Figure 2. System Framework as adapted from Design of Mobile Game Based Learning Application for Children with Dyslexia [29]

The learner's characteristics which comprise the learners' behaviour, age and learning motivation was first identified in order to determine how and what application is applicable. According to a preschool teacher, pupils at a very early age of 3 or 4 years old often get easily bored in the class.

The learning objectives or otherwise known as learning outcomes are what students are expected to achieve after an activity. Learning content consists of topics, themes, beliefs, behaviors, concepts and facts [30]. These are basically the materials used in the delivery of learning.

Game design, user interface and navigation, and content delivery and presentation, were used to determine how the application is presented to the user.

Feedback and assessment were utilized for the improvement of the application.

Figure 3 presents the system architecture of the study. The researcher utilized Android Studio for developing creative user interfaces, Java for the programming language, Firebase for the database and XML for the design.

The curriculum and learning materials guides the teacher in the delivery of the lesson to the preschoolers. The curriculum serves as input and guide as to the content of the application. GTM was utilized in the training of the model. A TensorFlow lite model was extracted and integrated in the application. The developed mobile application has interfaces for Alphabets, Animals, Objects, Fruits, Vegetables, Vehicles, Shape, Colors and Spelling.

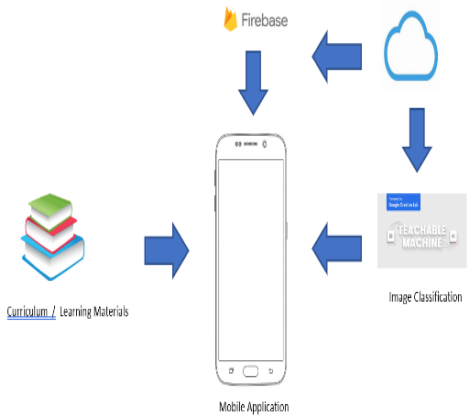

Figure 3. System Architecture

Figure 4 is the vegetable interface of the application. The user needs to tap the play button to listen to pronunciation of the name of the vegetable. The user can tap the previous or next button to check the next or previous vegetable image.

Figure 4.The Vegetable Interface

For the image recognition part, GTM was utilized for the training of the model. Twenty classes were used in the training where 85% were used to train the model as training samples and 15% for test samples. Figure 5 shows the accuracy per class of the trained model. The accuracy of the classes can be attributed to the number of images uploaded. More images would mean better accuracy in classification.

CLASS	ACCURACY	# SAMPLES
apple	0.83	144
mango	0.78	141
orange	0.60	146
rose	0.84	118
sunflower	0.93	110
cat	0.92	251
dog	0.96	730
potato	1.00	105
carrot	0.99	150
strawberry	0.82	147
brocolli	0.94	142
cow	0.91	225
grape	0.87	145
Lemon	0.77	142
Tomato	0.97	150
Bitter Gourd	1.00	150
Bottle Gourd	0.99	150
Butterfly	0.94	317
Horse	0.92	394
Elephant	0.92	217

Figure 5. Accuracy per class

Figure 6 shows validation and accuracy graph of the model which are very high. The accuracy of the training data set increases as the epochs increases. Whereas for the test data, it doesn't reach the 100 percent because these are images which were never seen by the model during training.

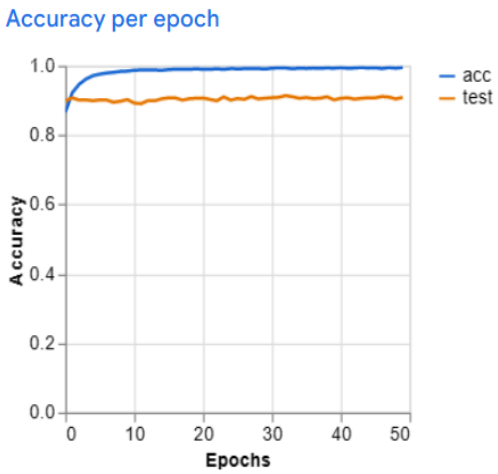

Figure 6. Accuracy per Epoch

Figure 7 presents a preview of the classification of an image. In selecting the image, the user has an option to use the camera or file. Once an image is selected, the classification and its accuracy of the image are shown.

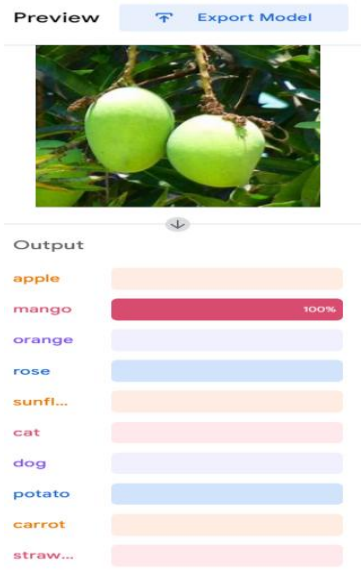

Figure 7. Classification Preview

3.2 Evaluation of the Mobile Based Game with Image Recognition for Preschoolers

The usability of the application was evaluated by 21 respondents consisting of sixteen (16) teachers and five (5) parents. A summary of the teachers' and parent's evaluation appears in Table 1.

Table 1: USE Tool Characteristics

Characteristics	Weighted Mean	Descriptive Rating
Usefulness	5.92	Agree
Ease of Use	6.32	Strongly Agree
Ease of Learning	6.37	Strongly Agree
Satisfaction	6.35	Strongly Agree
Total Weighted Mean	6.24	Strongly Agree

As presented in the table, the respondents agree that the application is useful with a weighted mean of 5.92, which means that the application is useful and effective as a tool for preschool learning. Ease of use got a weighted mean of 6.32 which implied that the application is simple to use, flexible and user friendly. For ease of learning, the respondents strongly agreed with a mean rating of 6.37 which means that the application is easy to learn to use. This can be attributed to the familiarity of preschoolers in using mobile devices and also the simplicity of the applications' interface. For Satisfaction, the respondents strongly agreed that the application is satisfying as evidenced with a mean rating of 6.35 which means that the application is fun and pleasant to use, works the way it should work, and would be recommended to a friend. The developed application is effective in achieving its goal which is a learning tool for preschoolers. The total weighted mean is 6.24 which has a descriptive rating of strongly agree, which means that the developed application was useful, easy to use, easy to learn and satisfying. This further implies that the application may be used by preschoolers as a supplementary tool for their learning.

4. Conclusion

This objective of the study was to design and develop a mobile based application with image recognition as supplement for learning for preschoolers. The use of image recognition is for preschoolers to identify and learn new objects or items. The use of GTM in training the model for image recognition was also used. A TensorFlow lite model was integrated in the application. The developed application was useful, easy to learn and use and

satisfying as rated by the respondents. The application has interfaces for learning basics of alphabets, animals, objects, fruits, vegetables, vehicles, shape, colors and spelling. The developed mobile based game presents a unique learning experience to preschoolers as it provides learning in a fun way. The developed application is suitable for preschoolers. With the advancements in technology, the development of applications for preschool learning is highly recommended as well as the use of educational digital games in the classroom. It is recommended that the application be further developed to cater to other platforms and screens. The use of better algorithms should be considered as well as the number of classes and images in the dataset.

References

[1] National Association for Education of Young Children. Effective Classroom Practice: Preschoolers and Kindergarteners. Available online at: https://www.naeyc.org/resources/topics/technology-and-media/preschoolers-and-kindergartners

[2] J. Natividad, A. Saavedra, E. Jainal, S. Toto, B. Marcial. Mother Tongue as a medium of communication and as an instrument for development among learners in the early childhood education. International Journal of Early Childhood Special Education. 10.9756/INT-JECSE/V14I4.114. 2022. Available online at: https://www.researchgate.net/publication/361658616_MOTHER_TONGUE_AS_A_MEDIUM_OF_COMMUNICATION_AND_AS_AN_INSTRUMENT_FOR_DEVELOPMENT_AMONG_LEARNERS_IN_THE_EARLY_CHILDHOOD_EDUCATION

[3] Hikmaturrahmah, R. Ruslin, Q. A'yun. An Analysis of the Assessment of Learning and Development in Early Childhood Education. 2022.Available online at: https://www.researchgate.net/publication/362536994_An_Analysis_of_the_Assessment_of_Learning_and_Development_in_Early_Childhood_Education

[4] A. Alviz. Utilizing Game-based learning in Explicit Instruction for Early Grades Reading Fluency. Munich, GRIN Verlag. 2018. Available online at: https://www.grin.com/document/436031

[5] M. Fang, O. Tapalova, N. Zhiyenbayeva, S. Kozlovskaya, Impact of Digital Game-Based Learning on the Social Competence and Behavior of Pre-Schoolers. 10.21203/rs.3.rs-707659/v1. 2021. Available online at: https://www.researchgate.net/publication/353423017_Impact_of_Digital_Game-Based_Learning_on_the_Social_Competence_and_Behavior_of_Pre-Schoolers

[6] M. Garcia, J. Mangaba. Delivering Effective Digital Game-Based Learning: A Comparative Study Between Computer and Mobile as the Learning Framework for Preschoolers. International Conference on Information Technology, Education, Engineering, and Management Sciences. 2017. Available online at: https://www.researchgate.net/publication/329139581_Delivering_Effective_Digital_Game-Based_Learning_A_Comparative_Study_Between_Computer_and_Mobile_as_the_Learning_Framework_for_Preschoolers

[7] N. Behnamnia, A. Kamsin, MAB Ismail, SA Hayati. A review of using digital game-based learning for preschoolers. J. Comput. Educ. 7:1–34. doi: 10.1007/s40692-022-00240-0. Epub ahead of print. PMCID: PMC9449305. September 2022. Available online at: https://www.researchgate.net/publication/363349032_A_review_of_using_digital_game-based_learning_for_preschoolers

[8] S. Rabu, Z. Talib. The Effects of Digital Game-based Learning on Primary School Student's English Vocabulary Achievement and Acceptance. Innovative Teaching and Learning Journal, 1(1), 61-73. November 2017. Available online at: https://www.researchgate.net/publication/321268645_The_Effects_of_Digital_Game-based_Learning_on_Primary_School_Students%27_English_Vocabulary_Achievement_and_Acceptance

[9] T. Partovi, M. R. Razavi. The effect of game-based learning on academic achievement motivation of elementary school students. Learning and Motivation. 68. 101592. 10.1016/j.lmot.2019.101592. 2019. Available online at: https://www.sciencedirect.com/science/article/abs/pii/S0023969019302498

[10] E. Byusa, E. Kampire, A. Mwesigye. Game-based Learning Approach on Students' Motivation and Understanding of Chemistry Concepts: A Systematic Review of Literature. Heliyon. 8. e09541. 10.1016/j.heliyon.2022.e09541. 2022. Available online at: https://www.researchgate.net/publication/

360894386_Game-based_Learning_Approach_on_Students%27_Motivation_and_Understanding_of_Chemistry_Concepts_A_Systematic_Review_of_Literature

[11] S. Kavak. DIGITAL GAME-BASED LEARNING MODEL AS AN EDUCATIONAL APPROACH. Prizren Educational Journal Vol 6 Issue 2. May - August 2022. Available online at: https://www.researchgate.net/publication/363169292_DIGITAL_GAME-BASED_LEARNING_MODEL_AS_AN_EDUCATIONAL_APPROACH

[12] University of San Diego. 43 Examples of Artificial Intelligence in Education. 2022. Available online at: https://onlinedegrees.sandiego.edu/artificial-intelligence-education/

[13] A. Singh. AI in Education: The Future of Teaching 2021. 2021. Available online at: https://www.globaltechcouncil.org/artificial-intelligence/ai-in-education-the-future-of-teaching-2021/

[14] Y. Pujari, D. Prasad, N. Malleswari, N. Gupta. Implementation of Machine Learning Based Google Teachable Machine in Early Childhood Education. International Journal of Early Childhood Special Education. 14. 4132-4138. 2022. Available online at: https://www.researchgate.net/publication/360438764_Implementation_of_Machine_Learning_Based_Google_Teachable_Machine_in_Early_Childhood_Education

[15] H. Vartiainen, M. Tedre, T. Valtonen. Learning machine learning with very young children: Who is teaching whom?. International Journal of Child-Computer Interaction. 100182. 10.1016/j.ijcci.2020.100182. 2020. Available online at: https://erepo.uef.fi/bitstream/handle/123456789/8284/15994712 60409123269.pdf?sequence=2

[16] S. AlZu'bi, R. Zitar, B. Hawashin, S. Shanab, A. Zraiqat, A. Mughaid, K. Almotairi, L. Abualigah. A Novel Deep Learning Technique for Detecting Emotional Impact in Online Education. Electronics. 11. 2964. 10.3390/electronics11182964. 2022. Available online at: https://www.researchgate.net/publication/3636 75314_A_Novel_Deep_Learning_Technique_for_Detecting_Emotional_Impact_in_Online_Education

[17] S. Chotitham, S. Wongwanich, N. Wiratchai. Deep Learning and its Effects on Achievement. Procedia - Social and Behavioral Sciences. 116. 10.1016/j.sbspro.2014.01.754. 2014. Available online at: https://www.researchgate.net/publication/275543465_Deep_Learning_and_its_Effects_on_Achievement

[18] [18]. J. Guo, S. Lee, H. Guo, J. Yang. Exploring Deep Learning of English Vocabulary Acquisition from Mobile Learning Environment. Journal of e-learning Research. 1. 1-16. 10.33422/jelr.v1i4.193. 2021. Available online at: https://www.researchgate.net/publication/364710604_Exploring_Deep_Learning_ of_English_Vocabulary_Acquisition_from_Mobile_Learning_Environment

[19] P. Kuppusamy, S. Joseph. A Deep Learning Model to Smart Education System. 2021. Available online at: https://www.researchgate.net/publication/356033546_A_Deep_Learning_Model_to_Smart_Education_System

[20] Unicef Philippines. The Benefits of Pre-School for Young Children. June 2018. Available online at: https://medium.com/@unicefphils/the-benefits-of-preschool-for-young-children-f666041bfd9d

[21] C. Handrianto, A. Jusoh, P. Goh, N. Rashid. Using ADDIE Model for Designing Instructional Strategies to Improve Teaching Competency of Secondary School's Teachers. E-Prosiding Webinar KonvensyenKaunselingKebangsaan Kali Ke-22, June 30, 2021. Available online at: https://www.researchgate. net/publication/352863787_Using_ADDIE_Model_for_Designing_Instructional_Strategies_to_Improve_Teaching_Competency_of_Secondary_Schools_Teachers

[22] Google's Teachable Machine. Available online at: https://teachablemachine.withgoogle.com/faq#Basics

[23] R. Etereo. An Introduction to Teachable Machine – AI for dummies. 2020. Available online at: https://blog.etereo.io/an-introduction-to-teachable-machine-ai-for-dummies-61d1f97f5cf.

[24] D. Johnson. What is TensorFlow? How it Works? Introduction & Architecture. November 2022. Available online at: https://www.guru99.com/what-is-tensorflow.html#:~:text=TensorFlow%20is%20an%20open-source%20end-to-

end%20platform%20for%20creating,on%20training%20and%20inference%20of%20deep%20neural%20networks.

[25] M. Gao, P. Kortum, F. Oswald. Psychometric Evaluation of the USE (Usefulness, Satisfaction, and Ease of use) Questionnaire for Reliability and Validity. Proceedings of the Human Factors and Ergonomics Society 2018 Annual Meeting. September 2018. Available online at: https://www.researchgate.net/publication/327934600_Psychometric_Evaluation_of_the_USE_Usefulness_Satisfaction_and_Ease_of_use_Questionnaire_for_Reliability_and_Validity

[26] M. Romero. Work, Games and Lifelong Learning in the 21st Century. Procedia-Social and Behavioral Sciences. 174. 115-121. 10.1016/j.sbspro.2015.01.634. 2015. Available online at: https://www.researchgate.net/publication/274393720_Work_Games_and_Lifelong_Learning_in_the_21st_Century

[27] S. Ishak, R. Din, U. Hasran. Defining Digital Game-Based Learning for STEM: A New Perspective on Design and Developmental Research (Preprint). Journal of Medical Internet Research. 23. 10.2196/20537. 2020. Available online at: https://www.researchgate.net/publication/346396858_Defining_Digital_Game-Based_Learning_for_STEM_A_New_Perspective_on_Design_and_Developmental_Research_Preprint

[28] R. Tangkui, T. Keong. Improving Achievements in Fractions: A Conceptual Framework for Digital Game-Based Learning Using Minecraft. 2021. Available online at: https://www.researchgate.net/publication/353193215_Improving_Achievements_in_Fractions_A_Conceptual_Framework_for_Digital_Game-Based_Learning_Using_Minecraft

[29] J. Torio, R. Bigueras, D. Maligat Jr, T. Palaoag, M. Arispe. Design of Mobile Game-Based Learning Application for Children with Dyslexia. 2022. Available online at: https://www.researchgate.net/publication/363212792_Design_of_Mobile_Game-Based_Learning_Application_for_Children_with_Dyslexia

[30] Learning Content. International Bureau of Education – UNESCO. Available online at: http://www.ibe.unesco.org/en/glossary-curriculum-terminology/l/learning-content