Learning Math through Mobile Game for Primary School Students

Nizirwan Anwar, Dedy Prasetya Kristiadi, Faris Ahmad Novezar, Patrick Alexander Tanto, Kein Septha, Prahastiwi Ardhia, Khalid Evan, Audrey Chrysler, Harco Leslie Hendric Spits Warnars and Juneman Abraham

Abstract— The covid19 pandemic today has made our children do their education at home and it makes another problem for parents to educate their children. This paper gives the solution by designing the model of learning where for currently will limit only in Math subject and have plans for implementation in many subjects as well. The proposed model of learning will be designed in games where can attract the students to learn by playing the game, and unconsciously, they will learn math while they play the games. The implementation of math learning using games will make the way to learn in fun and entertainment ways and at the end of the day, it will improve the student's math knowledge. The games model was designed with a use case diagram that shows the process of the mobile game activities, the User interface as prototyping the implementation and using a class diagram for database model design. Making this mobile game application better than features such as user feedback, user rating, and forum are added as a complement to make it user-friendly mobile games application.

Index Terms— Mobile game application, Electronic Learning, Mobile Learning, Primary School mobile game

I. INTRODUCTION

AS we enter the technology era, almost everything's changed, and we want to improve our next generation by learning not just in school, but we want them to learn outside school too. The Internet is playing a big role in children's s life nowadays as they prefer to use and interact with the content and images on the screen rather than books and papers [21]. We know learning subjects at school can be quite stressful for kids, and that' s why we want to develop an e-learning app that is focusing on math subject s with the concept "educational games". E-learning (or eLearning) is a platform in the form of electronic media that focuses on education [19], [9]. E-learning includes various types of media that enable students to learn through videos, audios, text, images, animation, and many more [20].

E-learning is advantageous for students. There are several benefits to online learning [7]. With online learning, students can access the content everywhere and anywhere they are with an unlimited number of times. There are days when the student could not attend school/lecture, so they have to learn the topic on their own. With E-learning, students do not have to worry about the lessons they have missed. Learning online also makes student in synchronizing with modern learners. With E-learning, students could access updated content with more creative concepts and ideas, unlike books. Another benefit of online learning is that it saves time. Students can define their

Nizirwan Anwar with faculty of Computer Science, Esa Unggul University, Jakarta Indonesia 11510 (email: nizirwan.anwar@esaunggul.ac.id)

Dedy Prasetya Kristiadi with Computer Science department at Raharja University, Tangerang Indonesia 15117 (email: dedy.prasetya@raharja.info)

Faris Ahmad Novezar, Patrick Alexaner Tanto, Kein Septha, Prahastiwi Ardhia, and khalid Evan are with Information Systems department, School of Information Systems, Bina Nusantara University, Jakarta Indonesia 11530 (email: fariz.novezar@binus.ac.id, Patrick.tanto@binus.ac.id,

kein.septha@binus.ac.id, prahastiwi.cahyani@binus.ac.id, khalid.thirafi@binus.ac.id).

Audrey Chrysler is with Computer Science department, School of Computer Science, Bina Nusantara University, Jakarta Indonesia 11530 (email: Audrey.chrisler@binus.ac.id)

Harco Leslie Hendric Spits Warnars is Associate Professor at Computer Science department, BINUS Graduate Program – Doctor of Computer Science, Bina Nusantara University, Jakarta Indonesia 11530 (email: spits.hendric@binus.ac.id)

Juneman Abraham with Psychology Department in Faculty of Humanities at Bina Nusantara University, Jakarta Indonesia 11530 (email: juneman@binus.ac.id)

speed of learning instead of waiting or following the speed of their peers. Each student has different abilities to think and study. One might not want to cover this specific area anymore but others need to focus on that area, which is a total waste of waiting time. Students also do not have to travel to the learning value as they can sit on their desks comfortably at home.

It is tremendously important to start early on a child's education, as there is a long-term benefit that can have an impact on their future [10]. The application focuses on math because math is one of the most challenging subjects for students [1]. Therefore, developing an E-Learning for math will change the perspective of students when learning math [6], [12].

Teaching young children is difficult because they lose interest very quickly so the game, we want to develop will have 5 chapters consisting of 10 levels, each chapter will be a tutorial lesson of how to solve a subject creatively. I f the users have already completed each chapter, they can unlock certain rewards. Every level passed will be given 3 diamonds to be used for hints on the next level when the user is struggling[23].

Not all kids will be able to use E-learning since there are low-income families that have no access to the internet. Even though an application is developed to support E-Learning, it will not be accessible to every student since there are people who are not exposed to the latest technology advancement. The demographics with less exposure to technology, only gain knowledge and education from school [17], [18].

Promoting E-learning in the form of games can be challenging since most parents have a negative perspective on online games [14]. Due to the impression that online games are not considered an educational tool. They are not familiar with the concept of online learning through games. Adults worry that playing games might have a bad impact on their children's behavior [22]. They are also concerned that children will prefer to play a game instead of socializing outside the house [19], [21].

With the proliferation of technology advancement today more resources can be utilized to deliver education.[24][25] Educating can be delivered beyond the school classroom, with the technology today it can be through the use of internet and games as the most important eLearning component[26][27]. eLearning may be termed as a network-enabled

transfer of skills and knowledge, and most of that as knowledge transformation. E-Learning can is perceived as something unfamiliar with parents, however, with the constant exposure to the technology they can receive a better understanding that children can learn through the internet and online games intended to educate them[28][29]. Furthermore, E-learning has its benefits that can help improve the learning process where it equips students with knowledge that can be retrieved online[30]. Online learning through games has its advantages, by learning individually, it enables students to learn at their own pace in the way of fun and entertain atmosphere as when they learn as they play the game itself [31].

II. PREVIOUS RESEARCH

Before "Mathsol", a similar application is developed to aid online learning called "e-learning tool for kids in Mauritius". The education of Mauritius was is modeled according to the British system since it was previously colonized by them. After being independent of the British, the government has focused on and prioritize the education of the country [16]. By focusing on education, the country will be able to tackle challenges in various industries such as regarding investments and resources. Their e-learning tool is to be customized for Mauritian kids. The online e-learning system platform is on a web-application. The website is focused on students between the age of 8 to 16 years old. With the web-application implemented as part of the education system, it has improved the quality of the education that aids self-learning among students [5].

Aside from that, there is another previous research called "E-Learning and Its Effects on Teaching and Learning in a Global Age". The research was developed to support the learning process by being able to interact through the web-application [5]. By implementing e-learning and having the platform, various resources are required such as faculty, money, time, and other resources. As with other educational materials, there are two major approaches to the evaluation of e-learning which are the process and its outcomes [9].

III. PROPOSED IDEA

There are roughly 5 million households in the world with children who do not have Internet access at home. This can affect a student's academic performance as they can't connect with people, do independent research, or do online homework. The solution to the first problem is, they do not always have to do it at home because the government has now provided us with free Wi-Fi in every place, allowing students to access the Internet and complete their works. If they do not have a smartphone, they can access it through computers because our E-learning is also available in the form of the website. Parents could now think about putting the Internet at home for good. And if the children still do not understand how to play the game even though they have been given a tutorial, the developers can create a discussion forum where children can ask the "expert" to help solve problems that the user is having difficulties [11].
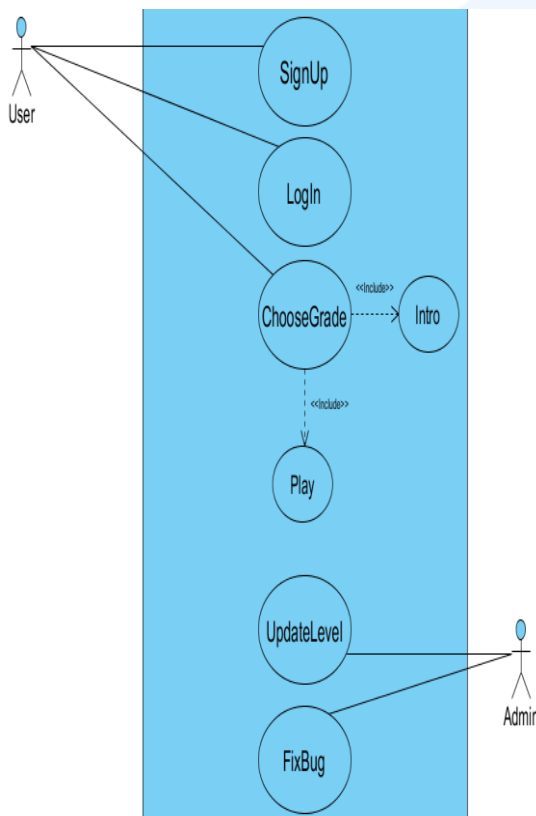

Fig. 1. Use Case Diagram of the mobile games application

Teaching young children has its challenges due to the limited attention span [11]. Therefore, by developing a game-based application, it will help keep the learning process interesting and regardless of their age, children like to play online games [13]. The application will be made as interactive as possible therefore the user will be intrigued and will be interested in solving the existing challenges [15].

All parents want their children to receive the best education. Using technology to study is foreign to most parents, as they didn't get this when they were still at school [11]. If parents want the best education for their child, they have to be familiar with E-learning platforms because, in this era, all people are moving to the technology. If parents do not believe if their children have been playing or studying, they can easily log in to the parent's account to check their kid's activities [15].
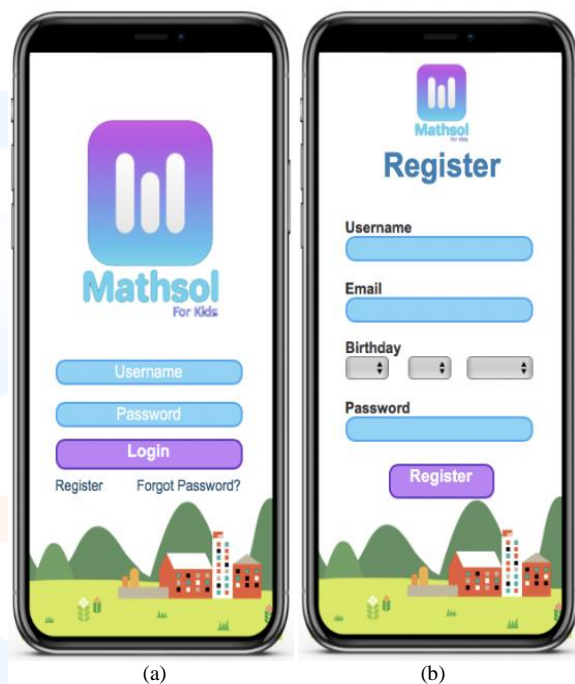

Fig. 2. (a) Login user interface, (b) Sign up user interface

In fig 1, we can see the use case for our mobile games application, which explains the interaction between two actors (user & admin) with the system. The user before using the mobile games application should download from play store, do the registration and then they can log in to it, choose the grade they want to master, and finally play the games provided. Moreover, the admin role is to update the level of the user after they have completed the level and also must fix the bug daily to prevent software problems.

Figure 2(a) shows the user interface when the user should enter their username and password before login to the mobile games application as the process is shown in the use case diagram in figure 1. Moreover, figure 2(b) shows the user interface when the user should do the registration as seen in the use case diagram in figure 1 by entering their information such as username, email, birthday, and password.
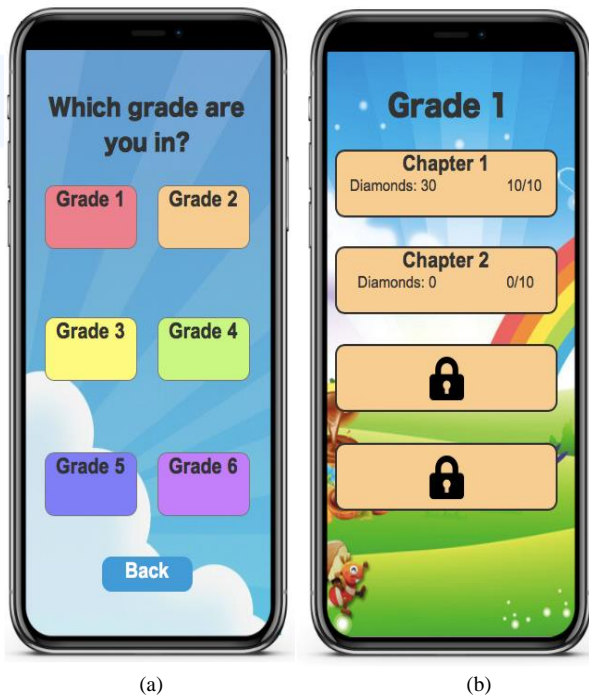
first level is open automatically and other next chapters will be opened depending on when the user player can finish for playing the game in the previous chapter. As seen in figure 3(b), it is shown that the rest of the chapters are still locked and to unlock it, the user player must complete the previous chapter.

(a)   (b)

Fig. 3. (a) user interface of choosing grade, (b) User interface of Grade 1

(a)   (b)

Fig. 4. User interface of Intro grade 1, (b) User interface of level 1

After the user do the login as seen in figure 2(a) then, the user can directly choose their school's grade as shown in figure 3(a), where this mobile games application is preferable for kids and the materials provided only for primary school students from grade 1 until grade 6. The optional grade will be influenced by the age of user player, were 1st grade for age 6 to 7 and 6th grade for age 12 to 13. However, the user player can freely choose which grade that they want to play for it and the content of the math subject should be different for each grade as refer to the primary school curriculum. As seen in figure 3(a) each grade will be colored differently to make it easy for users to differentiate.

For example, if the user chooses grade 1, then they can click it and it will be directed to the user interface as seen in figure 3(b) were content with some chapters with some level games each. The first chapter as the

Once the user opens the chapter box, it will be directed to the introduction page like seen in figure 4(a). It gives a summary of what lessons will be learned in that chapter. Users can click the "watch tutorial" button if they still need more explanation about the topic and need an assistant. If not, the user can just start the game or go back to the chapter page. In figure 4(b), it is the first level of the chapter, which is assigned math's addition. Users will be given 3 choices for them to choose which one is the right answer to the question given. Since the user hasn't answered any levels yet, their diamond remains 0 so they are not able to use the hint. We are using an apple image for the counting to make it more fun because kids tend to despise seeing numbers on the problem-solving.

Figure 5 shows the model database design for the mobile games application which content with 8 tables database such as user, userGrade, UserPlaying,
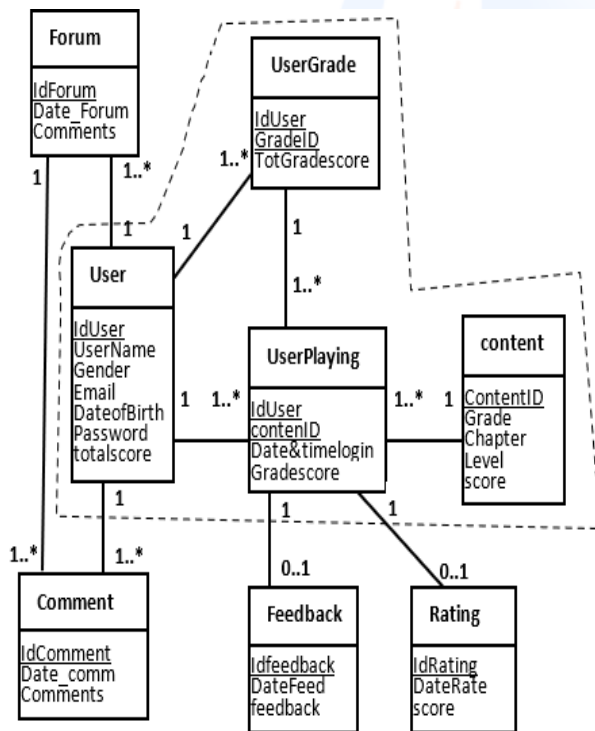
Fig. 5. Class diagram of mobile games application

content, forum, comment, feedback, and rating, where the four tables inside dot line as main tables while other tables as supporting tables. Thus, tables such as user, userGrade, UserPlaying, and content are main tables which are related to main games process of mobile games application whilst tables such as forum, comment, feedback, and rating are supporting tables which complete the mobile games application with supporting features such as a forum, feedback, and rating.

1. Table User.

   Table user as data user player recording has a purpose to record user player data such as username, gender, email, dateofbirth, password, and totalscore, where attribute totalscore is collected from every user player's activities as recorded in table userplaying. Moreover, attribute totalscore in table user with primary key IdUser which is also collected from every attribute TotGradeScore from table Usergrade.

2. Table UserGrade.

   Meanwhile, table usergrade is a table that contains the summarize score playing for each grade level, and so why tables user and usergrade has 1 to many associations where each user player can play in any available grade in table content. Moreover, since table usergrade as grade

summarization score, then every playing in each any grade level in table userplaying will be summarized per grade in table usergrade and so why tables usergrade and userplaying has 1 to many association. Table usergrade has a similar primary key with table User or sometime this table usergrade can be called a weak class, where its primary key depends on strong class where in this case is table user. Thus, table usergrade is grade score summarization which summarizes score per grade level where GradeID as grade identification with six options grade.

3. Table UserPlaying.

   Moreover, table userplaying is a table that records every user player's activities such as date and time to log in the system and the grade level that they play for it and the grade score when they play on that grade level. Each user player can play the games in many times so why table user to table userplaying has 1 to many association. Table user playing has a primary key as a composite key which is a combination of two foreign keys like Iduser+ContentID, where foreign key Iduser refers to table user and foreign key ContentID refer to table content. Table userplaying has 1 to many association with table content where it means that when the user plays the games then it will be recorded as one record when playing in any level game in the chapter as part of grade level.

4. Table Content.

   This table is a table that content with questions that are showed in mobile games application, including a score for each question, which was arranged in grade, chapter, and level, where there are six grades and each grade has many chapters and each chapter has a level. The composition of attributes grade, chapter, and level will as Primary key for attribute ContentID which refers to a list of questions that will be shown in the mobile games application. This table content is only related to table userplaying which has 1 to many association where each content played will be recorded in one record in table userplaying.

5. Table forum.

   Table forum is a table database recording for online discussion as a complementary feature for this mobile game application where user player can share their knowledge regarding this mobile game application and primary school education. User player can raise many threads as possible, so why table user has 1 to many association to

table forum. Table forum has primary key Idforum and two attributes such as date_Forum and Comments which record the date and time when the thread is raised and the thread's information. Moreover, attribute IdUser will add as a foreign key in table forum which related to Primary key in table User. As we are already known, a thread is a new discussion started and can be replied by many other user players and table comment is a complement for table Forum.

6. Table comment.
Table comment is the complement for table forum where each thread in each record in table forum can be replied with many comments and so why the table comment has 1 to many association with table forum. Moreover, 1 to many association between table comment and User shows that user players can choose which thread comment that they want to reply and they can do repeatedly. Furthermore, The table comments equipped with other two attributes such as Date_comm which record the date and time when the reply is raised and reply's comments. Attribute Iduser will be added to this table as a foreign key to table user as confirmation who give the reply for the thread in table forum and attribute Idforum from table forum will be added as well as a foreign key to table forum as a relation that which forum's thread that they comment for it.

7. Table rating.
Another complement feature for this mobile game application is user rating where the user player can give a rating for each playing transaction where the questions for rating will be listed more detail in programming implementation and the score will be summed up in attribute score. Other attributes such as daterate will record the date and time when the rating is recorded. This table rating has 0..1 to 1 association to table userplaying where means that user after play the games can not (zero) and can give their rating regarding the games. Whenever the user does not give their rating then there is no record will be created. Composite key Iduser+Contentid in table userplaying will be added to table rating as a foreign key which confirms relation to that table.

8. Table feedback.
Giving feedback to the mobile game application is another feature that can help the system to maintain for future implementation where at the

end of the day by listening feedback from the user who uses this mobile game application will give significant future progress for this mobile game application as user-friendly mobile games application. All the feedback comment will be recorded at attribute feedback and the date and time will be saved in attribute Datefeed when the feedback comment is recorded

The same as table rating this table has 0..1 to 1 association to table userplaying where means that user after play the games can not (zero) and can give their feedback regarding the games. Whenever the user does not give their feedback then there is no record will be created. Also, composite key Iduser+Contentid in table userplaying will be added to table feedback as a foreign key which confirms relation to table userplaying.

IV. CONCLUSION

Education in this era is fascinating thanks to these modern technology kids could positively use the internet, although not all kids can experience these changes. We also hope that education authorities could give a solution to kids who couldn't afford modernize technology. E-Learning is just not a change in technology. Learners will also have access to millions or billions of knowledge modules, in many fields, E-Learning has become the default way to provide education because of its effectiveness.

One thing to note is that E-Learning is not intended to replace conventional methods and learning in the classroom, it aims to create an augmented learning environment where technology is used to deliver a combined range of teaching & learning techniques aimed at maximizing individual's participation.

Currently, the development of this game is still simple as it is and this game needs to be developed more detail. For future development, all the content attributes in each table should be developed and extended and there will be other tables as a compliment. The content of rating will be broken down into specific ratings as the specifications needed by the developer to make this mobile game application become better mobile games application and easy to use for particularly children in primary school ages.

REFERENCES

[1] Laato, S., Laine, T.H., Seo, J., Ko, W. & Sutinen, E. (2017). Designing a Game for Learning Math by Composing: A

Finnish Primary School Case, IEEE 17th International Conference on Advanced Learning Technologies (ICALT), 3-7 July 2017, Timisoara, Romania.

[2] Arias, Meghan. (2014). Using Video Games in Education, Journal of Mason Graduate Research, 1(2):49-69.

[3] Belina Elda. 2013. Perancangan Dan Implementasi Aplikasi E-Learning Versi Mobile Berbasis Android. Jurnal Usu. 4(3): 76-8

[4] Bente Meyer (2013), Game-Based Language Learning for Pre-School Children: A Design Perspective. Electronic Journal of e-Learning, 11(1):39-48.

[5] Koutromanos, G. (2020). Primary School Students' Perceptions About the Use of Mobile Games in the Classroom. In Papadakis, S., & Kalogiannakis, M. (Eds.), Mobile Learning Applications in Early Childhood Education (pp. 230-250). IGI Global. http://doi:10.4018/978-1-7998-1486-3.ch012

[6] Kyriadikes, A.O., Mavrotheris, M.M. & Prodromou, T. (2016). Mobile technologies in the service of students' learning of mathematics: the example of game application A.L.E.X. in the context of a primary school in Cyprus, Mathematics Education Research Journal, 28:53–78.

[7] Chen, Y.L. & Hsu, C.C. (2020). Self-regulated mobile game-based English learning in a virtual reality environment, Computers&Education, 154.

[8] Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011) Gamification using game-design elements in non-gaming contexts., CHI 2011 workshop, may 7-21 Vancouver, Canada, pp.2425-2428.

[9] Kim, J.C., Lindberg, R.S.N., Laine, T.H., Faarinen, E.C., Troyer, O.D. & Nygren, E. (2019). Multidisciplinary Development Process of a Story-based Mobile Augmented Reality Game for Learning Math, 2019 17th International Conference on Emerging eLearning Technologies and Applications (ICETA), Stary Smokovec, Slovakia.

[10] Costa, M.C., Manso A. & Patricio, J. (2020). Design of a Mobile Augmented Reality Platform with Game-Based Learning Purposes, Information 11(3):

[11] Jagust, T., Boticki, I., Mornar, V. & So, H.J. (2017). Gamified Digital Math Lessons for Lower Primary School Students, 6th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI), 9-13July 2017, Hamamatsu, Japan.

[12] Castillo, R.E., Cheng, C.J., Agustin, J.S. & Aragon, M.C.R. (2019). Development of an Educational Mobile Game Applications for Grade 5 for Knowledge Channel Inc., Proceedings of the 2019 2nd International Conference on Information Science and Systems, March 2019, pp. 99–104.

[13] Stappen, A.D.R., Liu, Y., Xu, J., Yu, X., Li, J. & Spek, E.D.V.D. (2019). MathBuilder: A Collaborative AR Math Game for Elementary School Students, CHI PLAY'19, October 22–25, 2019, Barcelona, Spain.

[14] Lee J., Hammer J. (2011) Gamification in Education: What, How, Why Bother? Academic Exch. Quarterly, 15(2):1-5.

[15] Bahauddin, A. & Setyaningrum, W. (2019). Teacher's and prospective-teacher's perceptions of mobile math game "Proadventure" implementation in mathematics learning, IOP Conf. Series: Journal of Physics: Conf. Series 1320.

[16] Yallihep M. & Kutlu B. (2020) Mobile serious games: Effects on students' understanding of programming concepts and attitudes towards information technology, Education and Information Technologies, 25:1237–1254.

[17] Fabian, K., Topping, K.J. & Barron, I.G. (2018). Using mobile technologies for mathematics: effects on student attitudes and achievement, Educational Technology Research and Development, 66:1119–1139.

[18] Juric, P., Bakaric, M.B. & Matetic, M. (2018). Design and Implementation of Anonymized Social Network-based Mobile Game System for Learning Mathematics, International Journal of Emerging Technologies in Learning (iJET), 13(12):83-98.

[19] ÇİFTCİ S. (2018). The Studies on Educational Digital Games Regarding Children: A New Word Analysis Approach. The Turkish Online Journal of Edu Tech., 17(2): 158-168.

[20] Nygren, E., Blignaut, A.S., Leendertz, V. & Sutinen, E. (2019). Quantitizing Affective Data as Project Evaluation on the Use of a Mathematics Mobile Game and Intelligent Tutoring System, Informatics in Education 18(2):375–402.

[21] Deng, L., Tian, J., Cornwell, C., Phillips, V., Chen, L. & Alsuwaida, A. (2019). Towards an Augmented Reality-Based Mobile Math Learning Game System, International Conference on Human-Computer Interaction, pp. 217-225.

[22] Gok M., Inan M. & Akbayr K. (2020). Examining mobile game experiences of prospective primary school teachers and their game designs about teaching math*, Elementary Education Online, 19(2):641-666.

[23] Sunandar, Buchori, A., Rahmawati, N.D. & Kusdaryani, W. (2017). Mobilemath (Mobile Learning Math) Media Design with Seamless Learning Model on Analytical Geometry Course, International Journal of Applied Engineering Research, 12(19):8076-8081.

[24] Yasemin Allsop (2015). Learning on Gaming: A New Digital Game Based Learning Approach to Improve Education Outcomes. Int. Journal of Game-Based Learning, 5(1), 1-17.

[25] Yien, J. M., Hung, C. M., Hwang, G. J., & Lin, Y. C. (2011). A game-based learning approach to improving students' learning achievements in a nutrition course. The Turkish online journal of educational technology, 10(2), 1-10.

[26] Bano, M., Zowghi, D., Kearney, M., Schuck, S. & Aubusson, P. (2018). Mobile learning for science and mathematics school education: A systematic review of empirical evidence, Computers & Education, 121:30-58.

[27] Tan, C.W., Yu, P.D., Lin, L., Fung, C.K., Lai, C.K. & Cheng, Y. (2017). Teaching Computational Thinking by Gamification of K-12 Mathematics: Mobile App Math Games in Mathematics and Computer Science Tournament, Conference Proceedings of International Conference on Computational Thinking Education 2017. pp. 55-59.

[28] Cruz, B., Marchesini, P., Gatto, G. & Concilio, I.S. (2018). A mobile game to practice arithmetic operations reasoning, IEEE Global Engineering Education Conference (EDUCON), 17-20 April 2018, Tenerife, Spain.

[29] Kay, R. & Kwak, J.Y. (2018). Comparing types of mathematics apps used in primary school classrooms: an exploratory analysis, Journal. of Comp. in Edu., 5:349–371.

[30] Jagust, T., Boticki, I. & So, H.J. (2018). Examining competitive, collaborative and adaptive gamification in young learners' math learning, Computers&education, 125:444-457

[31] Deslis, D., Kosmidis, C.V. & Tenta, E. (2019). Using a Non-educational Mobile Game for Learning in Biology, Geography and Mathematics: Pokémon Go as a Case Study, International Conference on Technology and Innovation in Learning, Teaching and Education, pp.388-396.