Letters in Information Technology Education (LITE)
Vol 6, No 2, 2023, pp. 44 – 50
e-ISSN: 2654-5667

Gamification-based Mobile Learning Development for Vocational High School Student Software Modeling Learning

Muhammad Ridho Rifansah[1,*], Wahyu Nur Hidayat[a,2], Kokom Komariah[b,3]
[a] Faculty of Engineering, Universitas Negeri Malang, Malang, Indonesia
[a] Fakultas Teknik, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia
[1] muhammad.ridho.1905336@students.um.ac.id*; [2] wahyu.nur.ft@um.ac.id; [3] kokom@uny.ac.id
* corresponding author

Article Info

Article history:
Received: Jul 23, 2023
Revised: Oct 5, 2023
Accepted: Oct 17, 2023

Keyword:
Mobile learning
Gamification
Problem-based learning
Motivation
Software modeling

ABSTRACT

Generation Z tends to use mobile devices in their daily lives, which can positively impact the affective, cognitive, metacognitive, and socio-cultural development of students. In addition, most students direct their frustrations into playing games to make it more relaxed and fun. Currently, Vocational High Schools (VHSs) in Indonesia, especially in Malang, are intensively looking for alternative learning methods where students are active and enthusiastic in participating in the learning process due to the COVID-19 pandemic, so innovation is needed in learning. Based on observations and informal interviews and distributing questionnaires conducted at Public VHS 12 Malang, VHS Nasional Malang, and Public VHS 1 Kepanjen, motivation to learn software modeling subjects is still lacking. Currently, books and PPTs are the main learning media used in the classroom. As a result, students lack the motivation to study the material independently. To overcome these problems, this research designs and develops mobile learning gamified and PBL. By applying the Systematic Education Design Cycle Iteration development model called ISDES, the gamified & problem-based mobile learning application is categorized as valid regarding material suitability (95% validity score from material experts), and media experts review 94% of valid media suitability. Meanwhile, the media reviewed in the small group were all valid: 84% in the small group test and 86% in the field test. The results showed that the results of the motivation test increased by 0.63% in the small-scale test & 0.56% in the large-scale test, both of which included a high increase in learning motivation. These results conclude that the media is valid and appropriate for student learning and increases learning motivation.

I. INTRODUCTION

The field of Information and Communication Technology (ICT) is growing rapidly and has a significant impact on the speed and innovation of education. ICT covers two aspects, namely Information Technology, which involves tools and information management, and Communication Technology, which involves the use of tools to send data between devices. Technology will have an impact on education in the future. [1]. As technology continues to evolve and be integrated into education, there is a need for innovative learning materials to engage and motivate students.

The use of learning media in education can increase student motivation and provide stimulation to continue learning. [2], [3], [4]. Research has shown that multimedia can enhance student memory and engagement, which are key factors in academic achievement. However, the learning media used in education are often limited to PowerPoint slides or traditional face-to-face explanations from teachers. To increase understanding, it will be very helpful for students to be able to visualize the application of material through the use of multimedia & the use of multimedia will provide benefits such as learning becoming more interesting, learning activities are not boring, and learning quality can be improved. [1].

In the 2013 curriculum, Software Modelling is a C3 category subject offered in the RPL VHS department as part of a vocational study program. This program aims to equip students with specific knowledge in software. The Software Modelling subject aims to provide understanding and mastery of knowledge and skills to design data flows according to the Software Modelling lesson concept. Still, students find it difficult to understand this material and use it when faced with real problems. The learning process of Software Modelling emphasizes the independence and problem-solving abilities of students. A series of learning sessions is necessary, and a learning support tool that can facilitate the difficulties faced by students is adequate. In addition, Software Modelling is a compulsory subject for students participating in the RPL program.

Based on observations and interviews in class XI of the RPL Department at Public VHS 1 Kepanjen, VHS Nasional Malang, and Public 12 Malang, it is known that some students are less motivated in learning software modeling characterized by falling asleep during learning, lack of understanding of the material and being passive during learning. This impact occurred after the COVID-19 pandemic when students were still used to learning from home and were not used to the school environment. The COVID-19 pandemic has brought changes that have impacted all fields, including education. [5]. Changes in education from online back to offline have impacts such as confusing students, students becoming passive, less creative, and productive, students facing stress, and reduced learning motivation. [6]. In education, motivation is considered a key determinant of learning. Motivation is important in education because it affects how much students pay attention and effort in learning. Teachers often try to increase motivation to increase student performance, persistence, and effort. Managing learning motivation is part of a teacher's duties [7].

Another problem that was found when distributing questionnaires at Malang National Vocational School, Malang 12 Vocational School, and Kepanjen 1 Vocational School was that there were several inhibiting factors in learning in software modeling subjects, namely as many as 46.2% stated that the lack of time in class to discuss the material as a whole was due to the media used by the teacher is through printed books & PPT with the lecture method. While 64.1% of students stated that they were more motivated when learning using the discussion method and, 71.8% of students preferred learning through learning media equipped with video & animation, and as much as 74.4% chose media with game elements such as Kahoot and Quizizz.

Gen Z tends to use mobile devices to access the internet and often use them for studying. [8]. Technological developments have had an impact on many aspects of people's lives, including the economy, politics, culture, arts, and education. The roles of traditional books, teachers, and teaching systems have changed due to advances in ICT, especially in education. Learning through mobile devices is one way of using ICT to help effective learning. Learning through mobile devices can have a positive impact on the affective, cognitive, metacognitive, and socio-cultural development of students. [9]. Based on observations and distribution of questionnaires to Class XI RPL students at Public VHS 1 Kepanjen, VHS Nasional Malang, and Public VHS 12 Malang, it was found that 100% of students had hand-held devices. In addition, most students direct their frustration to playing games to make them more relaxed and fun. Currently, VHSs in Indonesia, especially in the city of Malang, are actively looking for alternative learning methods where students are active and enthusiastic about participating in the learning process. The impact of the pandemic is also one of the reasons why learning innovation is needed. One potential solution is the gamification approach. [9].

Gamification is the process of using game elements to be adjusted in a certain field with the aim of making it more interesting, understandable, and creative. Where game elements are used to increase the motivation, involvement, and performance of students [10]. Mobile learning supported by gamification is more effective in terms of academic achievement than traditional teaching. [11], gamification attracts users' attention to academic development, increases engagement between them, and motivates them [12]. Students usually do not like long daily working hours but are willing to spend much time playing games. [13]. The previous statement was also supported by an online questionnaire distributed to TKJ students in class XI Public VHS 1 Kepanjen who studied Kahoot, a learning media containing gamification elements. [14], it was found that students were given a questionnaire about how excited/motivated they were when learning to use the Platform Kahoot. As many as 76% of students agreed, and 24% disagreed. So, the elements in Kahoot that apply this concept can be utilized in the learning process, and its implementation is assisted by digital technology, namely handheld devices.

The developed Gamification-based Mobile Learning contains Software Modelling subjects. This subject aims to deepen students' understanding and skills in making data flow designs/designs, which are in accordance with aspects of the Software Modelling curriculum so problem-solving skills are needed. The problem-based learning method is used to develop problem-solving skills effectively. This approach encourages students to engage with the material, ask questions, work on problems, and collaborate with their peers.

The Mobile Learning created will be developed through the Flutter framework. Flutter is an SDK for mobile application development developed by Google. Flutter is a cross-platform framework, aka an application that can be used on more than one platform. Applications created using Flutter can run on both the Android and iOS platforms. This will save time, so there is no need to learn the native language used on each platform [15]. On the official Flutter documentation page, there is information about the minimum OS requirements to run applications made with Flutter, namely on a smartphone device. The minimum OS required on Android is Android version 4.1 Jelly Bean & iOS Version 11. It is known that 95% of students have an Android smartphone type with Android OS 10 as the most widely used version, and 5% use the iPhone with the most used version, iOS version 12.0. Flutter is suitable for developing gamification features because there are many packages available that make development easier. One of the other advantages of using the Flutter application is its ability to combine several elements such as video, audio, images, quizzes, and text, which are elements that will exist in the development of this product. In

addition, this application offers various additional features that can improve its quality and functionality. Thus, the existing features and elements are expected to motivate students to study with higher enthusiasm in the learning process.

On the basis of the background of the problems described, the research entitled "Development of Mobile Learning based on Gamification and Problem-Based Learning to Increase Learning Motivation in Software Modelling for Vocational High School Students." The application of gamification in Mobile Learning using the Problem-Based Learning model is expected to make it easier for students to understand the material, increase student activity, and motivate students to learn.

II. METHODS

This research is research development or Research and Development (R&D). This research is intended to develop learning media products that are effectively used to overcome the problem of decreased student motivation after the COVID-19 pandemic. The development model applied in this research is the one developed by Tjeerd Plomp. The Plomp model was chosen by the researchers because this model has a higher level of flexibility than other models. Thus, the Plomp model was chosen for this study. There are three development phases, namely in the form of repetition of the process of analysis, design and development, evaluation, and revision, as shown in Figure 1 Iteration of the Systematic Education Design Cycle.

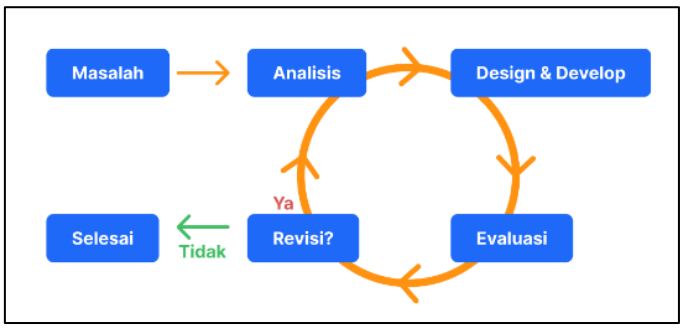

Fig. 1. ISDES stages

The process of systematic educational design is adjusted to the needs of the research to be carried out. The evaluation phase is carried out in three stages, namely the feasibility test, small group effectiveness test, and field effectiveness test. The stages that will be carried out are based on the educational design process systematically reviewing the evaluation stages carried out, namely analysis, design, development, due diligence, small group testing, field testing, and revision.

1. Analysis: The analysis phase aims to find out information about the needs of product development. This stage is divided into Analysis of student characteristics, Analysis of infrastructure, Analysis of curriculum, and Analysis of media; analysis is carried out by observing, interviewing, and distributing questionnaires to supporting teachers and students at Public VHS 1 Kepanjen, Public VHS 12 Malang and VHS Nasional Malang.
2. Design. The design phase focuses on preparing for product development. This stage involves creating a list of materials and tasks to be completed, designing the gamification implementation, creating the user interface and media flow, and outlining the gamification flow. Materials and assignments adapted to learning objectives. Problem-based learning is incorporated into student assignments or missions. The application of gamification and gamification flow is designed to increase student motivation for the product.
3. Development: the development phase is focused on creating products based on the designs made at the design stage. This stage begins with the development of materials, product appearance, and product systems. Material development includes creating media content such as animation, text, and images. Product display development connects users with the product system. A visually attractive and user-friendly appearance is important to motivate students towards the product. System development is carried out by incorporating elements of gamification and problem-based learning that have been outlined at the design stage into the product.
4. Feasibility Test: A Feasibility test is used to evaluate the product before it is used by students. This test is necessary to ensure the product is fit for use. The feasibility test is divided into two parts, namely, the media test and the material test. The media test assesses the application of gamification-based Mobile Learning to media using media test instruments conducted by media experts. The material test was carried out by material experts to evaluate the content of the material and the implementation of problem-based learning using the same media test instrument. If improvement is needed, the revision stage will be carried out. If the product is found to be satisfactory, it will proceed to the small group test stage.
5. Small Group Test: the product is tested in small groups after it is deemed ready for use. According to Branch [16], the optimal number of participants in a small group can range from 8 to 20 people. So, this product was tested by ten students from Public VHS 12 Malang specializing in RPL. Public VHS 12 Malang was chosen because there were problems with student motivation, and the school was looking for ICT-based learning alternatives to increase student motivation. In addition, schools are easy to reach, and the school is also willing to participate in research and provide the necessary support to ensure the smooth running of the research. The purpose of this trial was to determine the appropriateness of the media as well as to test motivation when used in a group setting. Testing is measured using the media test instrument & motivation test. If any corrections are required, revisions will be made. If the product is found to be satisfactory, the next phase, field testing, will proceed.

6. Field Tests Field tests are carried out after the product is tested in small groups. The subjects taken are the subjects that contain the most certain characteristics, traits, or characteristics found in the population. Referring to the statement above, the sample used at this stage is the field test conducted by 24 students of Public VHS 12 Malang majoring in RPL. The effectiveness test was conducted to assess students' motivation after using the product and the feasibility of the media when used in an actual field setting. The test is carried out by measuring the motivational test instrument and the media test instrument. If any corrections are required, revisions will be made. If the product is found to be satisfactory, it can be implemented in the field.
7. Product Revision: product revision is carried out to correct errors and perfect the product so that it can be used effectively & properly. These revisions occur when the product requires improvement. They occur after the feasibility testing, small group effectiveness testing, and field effectiveness testing stages have been completed. The revision process includes revision of the analysis phase, then proceeds to the design, development, and re-testing stages based on the results of the previous testing phase. Once no further revisions are required, the product can be used in educational settings.

III. Result and Discussion

This development research produces mobile learning media products based on gamification and Problem-Based Learning for software modeling subjects under the name "Brainboost Academy." This media was developed for students of class XI Software Engineering Skills Competency and tested with two stages of testing, namely, the expert validation stage, which consists of material validation and media validation, and the second stage of due diligence, which consists of small group trials and large group trials. Learning media "Brainboost Academy" consists of five main features, namely classes, achievements, Q&A, missions, and leaderboards. The following are the pages in the application, namely (1) The splash screen and onboarding pages in Figure 1. These are pages that will appear when opening the application and provide information about the application and the features contained in it: (2) The landing page in Figure 2. It consists of a login page, a list, a user manual, and developer information. Before entering the main page, there is information, and users are required to create an account first; (3) The homepage is in Figure 3. It consists of classes, user activities/achievements, and leaderboards. It is a page that contains all the achievements of the user as well as the main features and the gateway to enter the material and Q&A; (4) Class page in figure 4. Consists of the Material Tab and Q&A Tab. The material tab is a page that contains material, quizzes, and case studies, and the Q&A tab is a page that contains questions, comments, and a collection of case study answers.

Fig. 2. Splash Screen & Onboarding

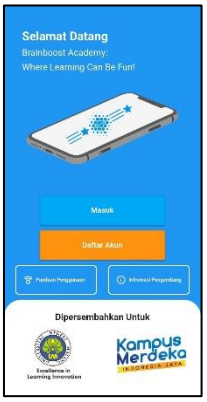

Fig. 3. Landing Page

Fig. 4. Homepage

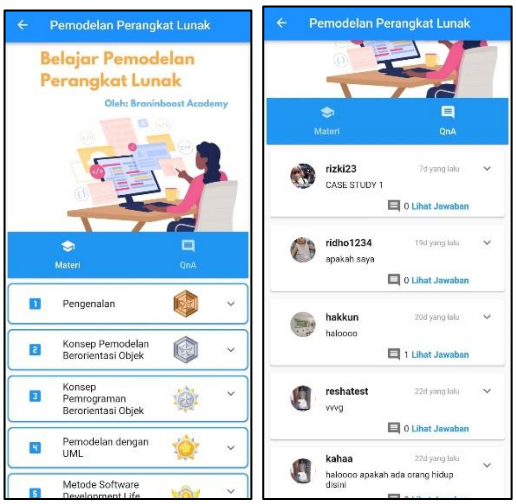

Fig. 5. Class Page

Before being tested on students, the developed application was tested on media experts and material experts.

TABLE I. Results of Media Expert Validation

No	Assessment Aspects	Indicators	Tse	Tsh	Percentage	Criteria
1.	*Potential effectiveness*	The use of effective applications in learning is carried out	24	25	96%	Very good
2.	*Usability*	The application provides an easy and useful interface for learning	24	25	96%	Good
3.	*Satisfaction*	The application used provides a sense of satisfaction in learning	14	15	93%	Very good
4..	*Accomplishment*	Students have the drive to achieve high grades	14	15	93%	Very good
		Students have the drive to successfully achieve learning goals	19	20	95%	Very good
5.	*Challenge*	Students have demands to study harder	9	10	90%	Very good
6.	*Competition*	Students compete with other students to get higher grades.	14	15	93%	Very good
7.	*Social experience*	Students interact socially with other students	14	15	93%	Very good
		Total	**132**	**140**	**94%**	**Very good**

The results of the combined media expert validation from the results of validation by teachers and validation results by lecturers get a percentage of 94% with very decent criteria consisting of seven aspects including aspects of Potential effectiveness, Potential effectiveness, Usability, Satisfaction, Satisfaction, Achievement, Challenge, Competition, Social experience.

TABLE II. Material Expert Validation Results

No.	Assessment Aspects	Indicators	Tse	Tsh	Percentage	Criteria
1.	*Self-Instruction*	Suitability of materials and learning objectives	10	10	100%	Very good
		Students can learn independently	24	25	96%	Very good
2.	*Self-Contained*	The material presented is complete	10	10	100%	Very good
3.	*Stand Alone*	Not dependent on other media	8	10	80%	Very good
4.	*Student-centered learning*	Student-centered learning	15	15	100%	Very good
5.	*Problem as stimulus*	The problems provided can stimulate students to think critically and learn independently	28	30	93%	Very good
6.	*Real-world problems*	The problems provided are according to conditions in society	19	20	95%	Very good

No.	Assessment Aspects	Indicators	Tse	Tsh	Percentage	Criteria
7.	*Self-directed learning*	Students organize their own learning	23	25	92%	Very good
		Amount	**137**	**145**	**95%**	**Very good**

The results of the material expert validation showed a percentage of 95%, which was based on very decent criteria. Validation consists of seven aspects, including Self Instruction, Self-Contained, Stand Alone, Student-centered learning, Problem as a stimulus, Real-world problems, and Self-directed learning.

The learning media was validated by material experts and media experts; then, trials were carried out on class XI RPL students at Public VHS 12 Malang, namely small-scale tests and large-scale tests to test the feasibility of the media that had been developed.

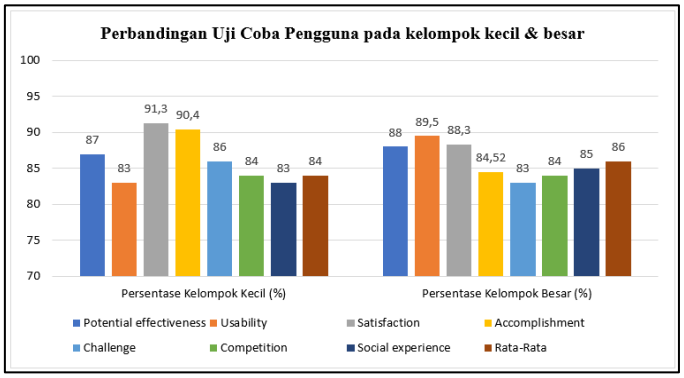

Fig. 6. User trials on a small & large scale

Overall, the percentage of results obtained in small group trials is 84%, and field trials are 86%. Brainboost Academy is classified as very feasible. Therefore, Brainboost Academy can be used to learn software modeling. Brainboost Academy can improve its quality in existing aspects so that it becomes a good gamification & PBL-based media.

Meanwhile, participating students were also asked to fill out a questionnaire about their motivation. Four aspects are asked in 18 questions, which include Attention, Relevance, Confidence, and Satisfaction. Participants must complete this questionnaire before and after using Brainboost Academy. Based on the results of the motivation test before and after using the media, the increase in motivation through N-Gain will be measured through the formula.

TABLE III Results of increased motivation in small and large groups

Small Group	Large Group
N-Gain of Attention aspect = 228 - 178250 - 178 = 0,69	N-Gain of attention aspect = 536 - 438600 - 438 = 0,60
N-Gain of relevance aspect = 220 - 170250 - 170 = 0,62	N-Gain of relevance aspect = 527 - 428600 - 428 = 0,57
N-Gain of confidence aspect = 172 - 132200 - 132 = 0,58	N-Gain of confidence aspect = 410 - 330480 - 330 = 0,53
N-Gain of satisfaction aspect = 176 - 136200 - 136 = 0,62	N-Gain of satisfaction aspect = 416 - 338480 - 338 = 0,54
N-Gain Total = 796 - 616900 - 616 = 0,63	N-Gain Total = 1889 - 15342160 - 1534 = 0,56

Increased motivation in small groups produces an N-Gain value of 0.63, which includes a high increase in motivation, & Increased motivation in large groups produces an N-Gain value of 0.56, which includes a high increase in motivation. Thus, the results of the study show that both in the small group and the large group test, there is a significant increase in students' learning motivation in the aspects of attention, engagement, self-confidence, and satisfaction with the media and the learning process. These results are in accordance with previous studies, which state that problem and gamification-based learning media can promote student motivation. [17], [18], [19], [20].

This research and development resulted in a learning media product called Brainboost Academy. Brainboost Academy applies the concept of mobile learning gamification and integrates problem-based learning models. Brainboost Academy contains Software Modeling material in the form of object-oriented modeling concepts and object-oriented system requirements. The material contained in Brainboost Academy is adapted to the 2013 curriculum. The material is presented using text, images, and videos.

IV. Conclusion

Based on the results obtained, it can be concluded that the research and development of gamification-based mobile learning media with the Problem-Based Learning model have fulfilled the research and development objectives, namely, Developing learning media products in the form of gamification-based mobile learning & PBL in Software Modelling subjects that have homepage features, messages, missions, rankings, and achievements. Brainboost Academy was developed using the research and development method of Systematic Education Design Cycle Iteration from T. Plomp. Brainboost Academy is tested on material experts and media experts before being tested on students. The test results from material experts get a percentage value of 95%, which is included in the very decent category. This shows that Brainboost Academy is feasible to implement in terms of material. The results of the media expert test showed a percentage value of 94%, which is included in the very decent category. Indicates that Brainboost Academy is feasible from a media standpoint. Brainboost Academy was tested on students in small group tests of 10 students & large groups of 24 students. The media test produces a percentage value of 84% in the small group, which is included in the fairly decent category & 86% in the large group, which is included in the very decent category. Motivation test is also applied to determine the level of student motivation using Brainboost Academy. Increased

motivation in small groups produces an N-Gain value of 0.63, which includes a high increase in motivation, & Increased motivation in large groups produces an N-Gain value of 0.56, which includes a high increase in motivation.

REFERENCES

[1] J. B. Romano Daba, Y. Rosmansyah, and B. Dabarsyah, "Problem-Based Learning Using Gamification: A Systematic Literature Review," in *Proceedings - 1st International Conference on Informatics, Multimedia, Cyber and Information System, ICIMCIS 2019*, Institute of Electrical and Electronics Engineers Inc., Oct. 2019, pp. 125–130. doi: 10.1109/ICIMCIS48181.2019.8985216.

[2] S. A. Licorish, H. E. Owen, B. Daniel, and J. L. George, "Students' perception of Kahoot!'s influence on teaching and learning," *Res. Pract. Technol. Enhanc. Learn.*, vol. 13, no. 1, pp. 1–23, Dec. 2018, doi: 10.1186/s41039-018-0078-8.

[3] H. Li, M. Y. P. Peng, M. Yang, and C. C. Chen, "Exploring the Influence of Learning Motivation and Socioeconomic Status on College Students' Learning Outcomes Using Self-Determination Theory," *Front. Psychol.*, vol. 11, p. 520709, Jul. 2020, doi: 10.3389/fpsyg.2020.00849.

[4] L. K. Fryer and H. N. Bovee, "Supporting students' motivation for e-learning: Teachers matter on and offline," *Internet High. Educ.*, vol. 30, pp. 21–29, Jul. 2016, doi: 10.1016/j.iheduc.2016.03.003.

[5] C. M. Chen, H. Liu, and H. Bin Huang, "Effects of a mobile game-based English vocabulary learning app on learners' perceptions and learning performance: A case study of Taiwanese EFL learners," *ReCALL*, vol. 31, no. 2, pp. 170–188, May 2019, doi: 10.1017/S0958344018000228.

[6] W. N. Hidayat, S. Patmanthara, S. M. Tosepu, T. A. Sutikno, and R. Wakhidah, "Gamified Mobile Learning for Digital Business Model Course," in *ICRACOS 2021 - 2021 3rd International Conference on Research and Academic Community Services: Sustainable Innovation in Research and Community Services for Better Quality of Life towards Society 5*, Institute of Electrical and Electronics Engineers Inc., 2021, pp. 290–295. doi: 10.1109/ICRACOS53680.2021.9702057.

[7] P. Buckley and E. Doyle, "Gamification and student motivation," *Interact. Learn. Environ.*, vol. 24, no. 6, pp. 1162–1175, Aug. 2016, doi: 10.1080/10494820.2014.964263.

[8] G. P. Mahapatra, N. Bhullar, and P. Gupta, "Gen Z: An Emerging Phenomenon," *NHRD Netw. J.*, vol. 15, no. 2, pp. 246–256, Apr. 2022, doi: 10.1177/26314541221077137.

[9] R. S. Pratama Putra Husmildin, H. Ar Rosyid, and H. Elmunsyah, "Developing Gamified Mobile Learning to Increase Student Motivation to Learn WAN Technology for Vocational High School Students," in *4th International Conference on Vocational Education and Training, ICOVET 2020*, Institute of Electrical and Electronics Engineers Inc., Sep. 2020, pp. 218–222. doi: 10.1109/ICOVET50258.2020.9229957.

[10] I. Suprianto, F. Pradana, and F. Abdurrachman Bachtiar, "Pengembangan Aplikasi E-Learning Dengan Menerapkan Metode Gamification," *J. Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 3, no. 2, pp. 1716–1724, 2019.

[11] C. H. Su and C. H. Cheng, "A mobile gamification learning system for improving the learning motivation and achievements," *J. Comput. Assist. Learn.*, vol. 31, no. 3, pp. 268–286, Jun. 2015, doi: 10.1111/jcal.12088.

[12] M. S. Kuo and T. Y. Chuang, "How gamification motivates visits and engagement for online academic dissemination - An empirical study," *Comput. Human Behav.*, vol. 55, pp. 16–27, Feb. 2016, doi: 10.1016/j.chb.2015.08.025.

[13] H. Jusuf, "Penggunaan Gamifikasi dalam Proses Pembelajaran," *J. TICOM*, vol. 5, no. 1, pp. 1–6, 2016, [Online]. Available: https://media.neliti.com/media/publications/92772-ID-penggunaan-gamifikasi-dalam-proses-pembe.pdf

[14] S. Wardana and E. M. Sagoro, "Implementasi Gamifikasi berbantu Media Kahoot untuk Meningkatkan Aktivitas Belajar, Motivasi Belajar, dan Hasil Belajar Jurnal Penyesuaian Siswa Kelas X Akuntansi 3 di SMK Koperasi Yogyakarta Tahun Ajaran 2018/2019," *J. Pendidik. Akunt. Indones.*, vol. 17, no. 2, pp. 46–57, Dec. 2019, doi: 10.21831/jpai.v17i2.28693.

[15] M. Fauzi, A. Teddyyana, and D. Enda, "Pengembangan Aplikasi Mobile Tanggap Bencana Di Kab. Bengkalis Menggunakan Framework Flutter," *Zo. J. Sist. Inf.*, vol. 3, no. 1, pp. 27–36, 2021, doi: 10.31849/zn.v3i1.5856.

[16] R. M. Branch, *Instructional design: The ADDIE approach*. Springer US, 2010. doi: 10.1007/978-0-387-09506-6.

[17] G. M. Chans and M. Portuguez Castro, "Gamification as a strategy to increase motivation and engagement in higher education chemistry students," *Computers*, vol. 10, no. 10, p. 132, Oct. 2021, doi: 10.3390/computers10100132.

[18] E. S. Rivera and C. L. P. Garden, "Gamification for student engagement: a framework," *J. Furth. High. Educ.*, vol. 45, no. 7, pp. 999–1012, Aug. 2021, doi: 10.1080/0309877X.2021.1875201.

[19] K. Welbers, E. A. Konijn, C. Burgers, A. B. de Vaate, A. Eden, and B. C. Brugman, "Gamification as a tool for engaging student learning: A field experiment with a gamified app," *E-Learning Digit. Media*, vol. 16, no. 2, pp. 92–109, Mar. 2019, doi: 10.1177/2042753018818342.

[20] R. Smiderle, S. J. Rigo, L. B. Marques, J. A. Peçanha de Miranda Coelho, and P. A. Jaques, "The impact of gamification on students' learning, engagement and behavior based on their personality traits," *Smart Learn. Environ.*, vol. 7, no. 1, pp. 1–11, Dec. 2020, doi: 10.1186/s40561-019-0098-x.