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Super Geo-Bros Game: A Scratch-Based Mathematics Game for Learning Geometric Transformations to Improve Learning Outcomes

Ajeng Nur Aulia Fitrianingsih, Rizky Rosjanuardi*, & Eyus Sudihartinih

Department of Mathematics Education, Universitas Pendidikan Indonesia, Indonesia

Abstract: This study aims to develop and evaluate the Super Geo-Bros game, an educational tool designed to assist ninth-grade students in understanding geometric transformations through interactive, Scratch-based technology. Following the ADDIE model, the research was conducted in five stages: analysis, design, development, implementation, and evaluation. The game allows students to interact with geometric shapes and perform transformations such as translation, rotation, reflection, and dilatation. Validation tests involving media and content experts demonstrated that the game is valid, practical, and effective, with a significant increase in students' learning outcomes. The gain score of 0.71 indicates a high level of improvement, showing that this game enhances engagement and facilitates better comprehension of abstract mathematical concepts.

Keywords: educational game, geometric transformation, mathematics learning, scratch, learning media.

▪ INTRODUCTION

Education is a fundamental need in human life. Through instruction and training, people go through several of positive procedures of self-development that lead to them becoming fully formed human beings. (Atalay, 2015; Saripudin et al., 2021). Education plays a crucial role in the development of a nation by producing skilled and high-quality human resources that contribute to the country's progress. This is in line with Law No. 20 of 2003 on the National Education System, which emphasizes the importance of education in fostering national advancement (Boyadzhieva, 2016; Vastyanov et al., 2021). Furthermore, in both formal and non-formal education, students are exposed to various fields of knowledge. So students must develop a strong interest in learning, as it greatly influences both the effectiveness of the learning process and the outcomes achieved (AlZoubi & Younes, 2015; Sidhu & Ying, 2017). In today's learning process, technology also serves as a key support, enhancing the effectiveness of education and making learning more accessible and engaging.

Technology as a learning medium can increase students' interest in mathematics. It can strengthen students' motivation and help them understand specific concepts. Additionally, technology can support students in connecting learning to real life and enable them to focus on decision-making and reflection (Guzel, 2010).

Technology has developed rapidly and supports various aspects of life, including education. Many schools, especially in developed countries, frequently utilize technology in the learning process. This is driven by the recognition that technology provides numerous benefits for both educators and students, including quick access to learning resources and the enhancement of skills in using electronic devices (Andreania & Ying, 2019; Pratama et al., 2023; Wibawa et al., 2023). Guzel & Gunhan (2010) stated that technology can facilitate problem-solving learning and develop deeper understanding. On the other hand, technology in the form of games can also be utilized in the learning

Rizky Rosjanuardi
*Email: rizky@upi.edu

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process. Since educational games work well when teaching subjects like mathematics that students find boring or difficult, teachers frequently employ them in their classrooms. By using educational games, teachers aim to boost students' interest in mathematics, resulting in positive effects on both the learning process and their academic outcomes (Fadella et al., 2018; Fearnley & Amora, 2020).

Educational games have rapidly evolved, providing new opportunities for teachers to integrate them into the learning process, making lessons more engaging and interactive for students. Before implementing games in education, teachers must enhance their knowledge and skills in using technology. Based on several researches, games in education are highly effective, such as boosting students' learning activities and helping to achieve learning objectives (Aprilliyah, 2014; Kalogiannakis & Papadakis, 2019; Lutfi & Hidayah, 2021). Moreover, educational games serve as an ideal solution for students to both play and learn. For subjects often perceived as difficult and unenjoyable, such as mathematics, games help support students throughout the learning process (Ahdhianto et al., 2020; Widyasari et al., 2019). Through games, students can better grasp the material and make the learning process more enjoyable (Fatimah & Santiana, 2017; Safitri et al., 2022).

Sherryl and Pacheco (2006) stated that games have great potential to maintain students' attention during the learning process. Furthermore, Sudargo et al. (2017) mentioned that games contain several elements that can encourage someone to keep playing for an extended period. These elements include attractive visuals, engaging content, and the enjoyment of completing one level or advancing to the next.

Educational games are designed to achieve specific learning outcomes. Additionally, educational games can be used as a medium to train students' skills in problem-solving, finding solutions, thinking quickly, and competing (Ardiningsih, 2019). The primary objective of educational games is to meet learning goals in line with expected outcomes, facilitate meaningful learning through the game process, and provide real-world representation through game simulations. Previous research by Bernard (2020) found that people tend to play until they understand how the game works. However, if the game process is replaced with educational games, and students understand mathematical concepts through the game, they may be able to master mathematics and become more motivated to learn.

Based on research conducted by Morsi and Jackson (2007), most students reported experiencing positive feelings, such as "happy" and "interested," when playing games. Bernard (2020) found that educational math games are enjoyable, allowing students to share ideas and appreciate mathematics. Additionally, Students displayed a strong curiosity about technology. Thus, the development of educational games for mathematics can transform students' mindsets, making mathematics a fun subject where concepts are easily understood, engaging, and motivating for learning. Consequently, students' learning outcomes can also improve.

The use of technology-based games in education has become a widely researched topic and has been proven effective in improving student's learning outcomes, particularly in subjects that require abstract understanding, such as geometric transformations. Vogel et al. (2006) concluded that interactive games provide a deeper and more effective learning experience compared to conventional methods, as they enhance student engagement. The context of the Super Geo-Bros game, allows students to directly interact

with geometric objects and visualize the results of transformations such as translation, rotation, reflection, and dilation. Connolly et al. (2012) stated that technology-based educational games can enhance students' understanding, especially in abstract mathematical concepts. The implementation of Super Geo-Bros aligns with these findings, as it facilitates the exploration of geometric transformation concepts through visual and interactive media, making it easier for students to comprehend.

Another study by Kiili et al. (2005) emphasized that educational games allow students to experience learning processes directly through simulation and experimentation, supporting the theory of experiential learning. In the Super Geo-Bros game, students can manipulate shapes and observe how each transformation affects the shape. Diniz et al. (2014) added that well-designed games can enhance students' motivation and cognitive engagement in solving mathematical problems. This is further supported by research from Huizenga et al. (2017), which found that technology-based games improve students' understanding through collaborative and interactive activities. Shute et al. (2009) found that games with integrated evaluation elements allow students to monitor their progress, enhancing reflection and metacognitive knowledge. Thus, Super Geo-Bros not only supports understanding of geometric transformations but also improves students' overall learning outcomes.

▪ METHOD

Participants

The study's population included 9th-grade students in Bandung who had not yet been exposed to geometric transformation material. Through purposive sampling, the participants consisted of 28 nineth-grade students from a school in Bandung City. Validation was performed by experts in learning media and educational content. This research took place in September 2024 and was part of the development of an educational game aimed at improving students' learning outcomes.

Research Design and Procedures

This research is a Research and Development (R&D). R&D is research to produce certain products and test the effectiveness of the product. This type of research is different from other educational research because the goal is to develop a product based on trials and then revise it to produce a suitable product for use. The development model referenced is the ADDIE model proposed by Dick and Carey (1978), which encompasses five key phases: analysis, design, development, implementation, and evaluation.

The use of the R&D and ADDIE model is considered appropriate because the focus of this study is to design and develop an educational game product as media for learning mathematics, particularly the concept of transformation geometry, the feasibility of educational quiz game products based on the experts' judgment and respondents' assessment, and the effectiveness test to determine the improvement of learning outcome of nineth-grade students.

The development of the educational games using the ADDIE model began with Stage 1: Analysis, which focused on identifying suitable educational games to address student's difficulties in learning mathematics, particularly geometric transformations for ninth-grade students. This stage involved observation and interviews. Stage 2: Design followed, where the game design was initiated by creating flowcharts and storyboards, as well as planning the types of assessments to be conducted. In Stage 3: Development, the

design was realized, and validation was carried out by media and material experts. Stage 4: Implementation aimed to gather user responses regarding the educational game. Finally, Stage 5: Evaluation involved assessing the game based on feedback from material experts, media experts, and respondents.

Instruments

The data were collected through observation, interviews, questionnaires, and tests. Observations and interviews were carried out during the preliminary test to determine students' learning conditions. Meanwhile, the questionnaire in the form of an evaluation sheet was used for experts' judgment and respondents' assessment. The test was carried out in 2 stages, namely the pre-test and post-test to identify the differences in students' learning outcomes before and after using the developed product. The obtained data were analyzed by compiling and grouping data, describing data, and drawing conclusions. Data analysis was carried out descriptively to explain the respondents' responses to tests, questionnaires, interviews, and observations.

Data Analysis

The research data was obtained in both qualitative and quantitative data. Qualitative data were obtained from interviews with teachers and critiques and suggestions from validators. Quantitative data was obtained through assessments using validation sheets, pre-test and post-test assessments, and student response questionnaires. The data collected were subsequently analyzed and processed using both qualitative and quantitative descriptive methods. Qualitative descriptive analysis is a method of interpreting or processing data that involves systematically compiling categories regarding a subject (objects, symptoms, or certain variables) in the form of sentences or words so that general conclusions can be drawn. In contrast, quantitative descriptive analysis is a method of processing data that involves systematically compiling numbers or percentages about an object under study in order to draw broad conclusions (Agung, 2012).

There are two data in this research, namely qualitative and quantitative data. Qualitative data were obtained from the validator. Quantitative data were obtained through assessment using validation sheets, pre-test and post-test assessments, and student response questionnaires. The data obtained were analyzed and processed using qualitative and quantitative descriptive methods. Qualitative descriptive analysis interprets or processes data by systematically assembling sentence/word categories about a subject (objects, symptoms, specific variables) to reach general conclusions. On the other hand, quantitative descriptive analysis is a data processing method that systematically compiles numerical data or percentages related to the object of study to draw general conclusions (Agung, 2012).

Data analysis aims to obtain valid, practical, and effective scratch media. Validity analysis is based on the results of the validation sheets from media experts and material experts. Validation sheet data will be analyzed for validity by:

$$Percentage\,(\%) = received\,maximum\,score \times 100\%$$

Learning media is considered valid if it has achieved more than 60% validity. Practicality analysis is conducted by analyzing data obtained from student response

questionnaires. Learning media is considered practical if it has reached a reasonably practical level above 70%. An effectiveness analysis is obtained based on pre-test and post-test results. N-gain calculation is used to see whether the developed media effectively improves student learning outcomes.

▪ RESULT AND DISSCUSSION

Super Geo-Bros Game

The mathematics educational games were developed through several stages: analysis, design, development, implementation, and evaluation. The analysis stage involved conducting observations and interviews. Observations of ninth-grade mathematics learning revealed that the teacher primarily employed lecture and practice learning methods, utilizing textbooks and worksheets as the main teaching materials. Additionally, the teacher provided instructional videos as supplementary resources. However, some students showed a lack of interest in watching these videos because they passively viewed them without engaging directly with the devices. Interviews with ninth-grade students indicated that many found mathematics challenging due to numerous confusing formulas and difficult problems, leading to a low interest in learning and negatively impacting their learning outcomes. A particular area of difficulty for students was the concept of geometric transformations, especially rotation and reflection.

Based on the analysis stage, the researchers proceeded to the second stage of the ADDIE model: design. During this stage, the researchers planned the development and testing of Scratch-based interactive games. This planning involved determining the educational material and exploring theories related to gamification media. The researchers then selected various elements, structures, audio, images, and typography that aligned with the learning material.

Furthermore, in the third stage, researchers created and developed an interactive Scratch-based game, "Super Geo-Bros". For its content, on the initial screen, there is a "skuy" button to proceed to the menu selection. In the menu screen, students can choose the geometric transformations material, which contains the basic concepts of geometric transformations and the geometric transformations game option. In the material option, several concepts are presented to enhance students' understanding of geometric transformations, along with some easy questions. In the game option, students can control GeoBros in a maze to go to the correct answer box. The interactive game Super Geo-Bros is shown in Figure 1.

In the implementation stage, the effectiveness of the previous step is evaluated. For the Scratch-based interactive media game, two experts, media experts and material experts, conducted tests. Validation was carried out by distributing questionnaires to these experts. After receiving their evaluations, the researchers tested the Scratch-based interactive media games on ninth-grade students. However, due to certain limitations, the researchers conducted field tests only. Media testing involved distributing links to pre-test and post-test questionnaires along with the Super Geo-Bros interactive game to the students. Students were given two days to complete the pre-test and post-test questionnaires and engage with the media. The process began with students filling out the pre-test questionnaire before using the interactive media. After completing the pre-test, students could use the media and subsequently fill out the post-test questionnaire.

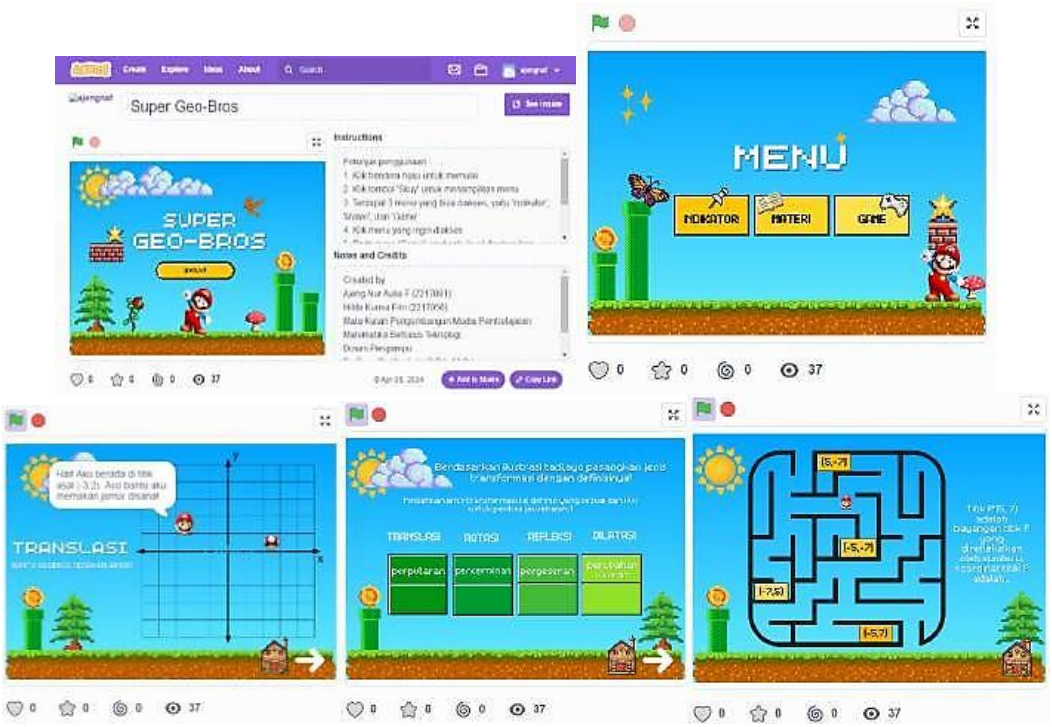

Figure 1. Interactive games super geo-bros

The final stage is evaluation. Several improvements are made to the Scratch software-based interactive learning media during the evaluation stage. Suggestions and input from validators, as well as teacher and student responses, are used to improve the Scratch software-based interactive media. Based on the needs analysis results in high schools, learning media can help students' understanding, especially in the regulatory system material. According to the research conducted by Nugraha & Widiyaningrum (2015) and Martanti et al. (2013), learning media based on Scratch software can facilitate students' understanding of the material presented by the teacher.

Based on the results of the assessment by media experts using a questionnaire covering aspects of media design, ease of use, and media support in Table 1. The average percentage of the validation by media expert was 85% and it was categorized as "very appropriate".

Table 1. Results of validation by media expert

No	Rated Aspects	Percentage	Category
1	Media Design	90%	Very Appropriate
2	Ease of Use	80%	Very Appropriate
3	Media Support	85%	Very Appropriate

Then, based on the results of the assessment by material experts using a questionnaire covering aspects of Material Quality, Material Coverage, Material Benefits and Linguistics in Table 2. The average percentage of the validation by media expert was 92,75% and it was categorized as "very appropriate".

Table 2. Results of validation by material expert

No	Rated Aspects	Percentage	Category
1	Material Quality	90%	Very Appropriate
2	Material Coverage	86%	Very Appropriate
3	Material Benefits	95%	Very Appropriate
4	Linguistics	100%	Very Appropriate

Then, based on the results of field test by student using a questionnaire covering aspects of Functions and Benefits, Program Presentation, Language and Typography in table 3. The average percentage of field tests was 97% and it was categorized as "very appropriate".

Table 3. Results of field tests

No	Rated Aspects	Percentage	Category
1	Functions and Benefits	97%	Very Appropriate
2	Program Presentation	94%	Very Appropriate
3	Language and Typography	100%	Very Appropriate

The Effectiveness of Super Geo-Bros Game to Improve Learning Outcomes

Based on the mean scores of the two tests, there is a noticeable increase from the pre-test to the post-test. The gain score, calculated using the two mean scores, resulted in 0.71. Because the gain score is more than 0.70, it is considered "high", so the use of educational games in learning mathematics of ninth-grade students can be said effective.

Table 4. Effectiveness test

	Pretest	Posttest
Minimum score	1	3
Maximum score	22	25
Mean	7.5	19.1
Gain Score		0.71
Category		High

The results of the practicality test conducted on a small scale, based on teacher and student responses, indicated that the media was very practical. Similarly, student responses during the field trial reflected a practical evaluation, as their suggestions and comments on the questionnaire revealed a strong interest in the Scratch interactive learning media. This is in line with the research of Arfiansyah et al. (2019), who indicated that the Scratch learning media is effective in engaging students, as evidenced by the numerous comments from students on the questionnaire and their active participation in the learning process, demonstrating their interest. Based on the results of the research of Chaerunnisa & Bernard (2021), also shows that the interest of primary school students is in a strong category when learning mathematics using scratch media.

The effectiveness test results found that Scratch interactive learning media can improve student learning outcomes, so it is very effective to use in learning. This is consistent with the findings of Permatasari et al. (2018) that scratch media can improve learning outcomes, as indicated by the percentage of completeness of student learning

outcomes that increases from cycle one to cycle two, and scratch media can also increase student motivation. Additionally, other studies indicate that there are differences in learning outcomes when using Scratch media compared to simpler media. Scratch media has a positive impact on learning outcomes, as it enables students to achieve higher scores (Husna et al., 2019; Ortiz-Colón & Romo, 2016).

Scratch software-based interactive learning media offers several advantages, including a combination of text, images, animation, and games, which can significantly aid students in understanding concepts more effectively. Consequently, this interactive learning media can enhance students' learning outcomes. This is supported by the findings of Diyana et al. (2020), who state that the integration of components such as text, images, and animation makes the media particularly suitable for clarifying abstract concepts and making them more concrete. Additionally, research by Korkmaz (2016) indicates that Scratch-based games contribute to increased academic achievement scores among students.

Based on the results of the validity, practicality, and effectiveness tests, the interactive learning media based on scratch software on the material of the regulatory system is declared to be valid, practical, and effective so that this learning media can be utilized by teachers in the learning process.

▪ CONCLUSION

The Super Geo-Bros game has been proven to be a valid, practical, and effective learning tool in helping students understand the concept of geometric transformations. The development of this game followed the ADDIE model and was validated by experts in media and content, with results showing high levels of validity, practicality, and effectiveness. The gain score of 0.71 reflects a significant improvement in student learning outcomes, indicating that the use of educational games in mathematics instruction can enhance student engagement and facilitate the understanding of abstract mathematical concepts.

Furthermore, the Super Geo-Bros game has successfully made the learning process more interactive and enjoyable, allowing students to more easily relate the material to real-life situations. The use of game-based technology also demonstrates great potential in creating a more personalized learning experience, where students can learn at their own pace and according to their individual needs. Thus, educational games like Super Geo-Bros play an important role in supporting the achievement of more optimal and in-depth learning outcomes, particularly in subjects often perceived as difficult, such as mathematics.

▪ REFERENCES

Agung, A. A. G. (2012). *Metodologi penelitian pendidikan*. UNDIKSHA.

Ahdhianto, E., Marsigit, Haryanto, & Nurfauzi, Y. (2020). Improving fifth-grade students' mathematical problem-solving and critical thinking skills using problem-based learning. Universal Journal of Educational Research, 8(5), 2012–2021.

Al-Zoubi, S. M., & Younes, M. A. B. (2015). Low academic achievement: Causes and results. Theory and Practice in Language Studies, 5(11), 2262.

Andreania, W., & Ying, Y. (2019). "PowPow" interactive game in supporting English vocabulary learning for elementary students. Procedia Computer Science, 157, 473–478.

Aprilliyah. (2014). *Pengembangan media pembelajaran modul interaktif pada materi jurnal khusus kelas X akuntansi di SMK Negeri Mojoagung.* Jurnal Khusus, 2(2), 1–7.

Ardiningsih, D. (2019). *Pengembangan game kuis interaktif sebagai instrumen evaluasi formatif pada mata kuliah teori musik.* Jurnal Inovasi Teknologi Pendidikan, 6(1), 92–103.

Arfiansyah, L. P., Akhlis, I., & Susilo. (2019). *Pengembangan media pembelajaran berbasis Scratch pada pokok bahasan alat optik.* Unnes Physics Education Journal, 8(1), 66–74.

Atalay, R. (2015). The education and the human capital to get rid of the middle-income trap and to provide the economic development. Procedia - Social and Behavioral Sciences, 174, 969–976.

Bernard, M., & Setiawan, W. (2020). Developing math games media using Scratch language. In Journal of Physics: Conference Series, 1657.

Boyadzhieva, E. (2016). Learner-centered teaching and learner autonomy. Procedia - Social and Behavioral Sciences, 232, 35–40.

Chaerunnisa, N. A., & Bernard, M. (2021). *Analisis minat belajar siswa sekolah dasar pada pembelajaran matematika dengan menggunakan media Scratch.* JPMI: Jurnal Pembelajaran Matematika Inovatif, 4(6), 1577–1584.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. Computers & Education, 59(2), 661–686.

Diyana, T. N., Supriana, E., & Kusairi, S. (2020). *Pengembangan multimedia interaktif topik prinsip Archimedes untuk mengoptimalkan student centered learning.* Jurnal Inovasi Teknologi Pendidikan, 6(2), 171–182.

Dick, W., & Carey, L. (1985). The systematic design of instruction. Scott, Foresman.

Diniz dos Santos, A., Strada, F., & Bottino, A. (2017). Investigating the design and evaluation of educational games under the perspective of player experience. In Lecture Notes in Computer Science (pp. 20–30).

Fatimah, A. S., & Santiana, S. (2017). Teaching in the 21st century: Students-teachers' perceptions of technology use in the classroom. Script Journal: Journal of Linguistic and English Teaching, 2(2), 125.

Fadella, E. F., Sugiarto, & Prabowo, A. (2018). *Keefektifan problem-based learning berbantuan komik matematika terhadap kemampuan pemecahan masalah dan rasa ingin tahu.* PRISMA (Prosiding Seminar Nasional Matematika), 77–86.

Fearnley, M. R., & Amora, J. T. (2020). Learning management system adoption in higher education using the extended technology acceptance model. IAFOR Journal of Education, 8(2), 89–106.

Guzel, E. B., & Gunhan, B. C. (2010). Prospective mathematics teachers' views about using flash animations in mathematics lessons. International Journal of Human and Social Sciences, 5(3), 154–159.

Huizenga, J., ten Dam, G. T. M., Voogt, J., & Admiraal, W. (2017). Teacher perceptions of the value of game-based learning in secondary education. Computers & Education, 110, 105–115.

Husna, A., Cahyono, E., & Fianti. (2019). The effect of project-based learning model aided Scratch media toward learning outcomes and creativity. Journal of Innovative Science Education, 8(1), 1–7.

Kalogiannakis, M., & Papadakis, S. (2019). Evaluating pre-service kindergarten teachers' intention to adopt and use tablets into teaching practice for natural sciences. International Journal of Mobile Learning and Organization, 13(1), 113–127.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. The Internet and Higher Education, 8(1), 13–24.

Korkmaz, Ö. (2016). The effects of Scratch-based game activities on students' attitudes, self-efficacy, and academic achievement. International Journal of Modern Education and Computer Science, 8(1), 16–23.

Lutfi, A., & Hidayah, R. (2021). Gamification for science learning media: Challenges of teachers and expectations of students. International Journal of Interactive Mobile Technologies, 15(01), 142–154.

Martanti, A. P., Hardyanto, W., & Sopyan, A. (2013). *Pengembangan media animasi dua dimensi berbasis Java Scratch materi teori kinetik gas untuk meningkatkan pemahaman konsep siswa SMA.* Unnes Physics Education Journal, 2(2), 20–25.

Morsi, R., & Jackson, E. (2007). Playing and learning? Educational gaming for engineering education. In Proceedings - Frontiers in Education Conference (FIE '07) (pp. 1–5). IEEE.

Nugraha, M. I., & Widiyaningrum, P. (2015). *Efektivitas media Scratch pada pembelajaran biologi materi sel di SMA Teuku Umar Semarang.* Unnes Journal of Biology Education, 4(2), 209–214.

Ortiz-Colón, A. M., & Romo, J. L. M. (2016). Teaching with Scratch in compulsory secondary education. International Journal of Emerging Technologies in Learning (IJET), 11(6), 67–70.

Permatasari, L., Yuana, R. A., & Maryono, D. (2018). Implementation of Scratch application to improve learning outcomes and student motivation on basic programming subjects. Indonesian Journal of Informatics Education, 2(2), 97–104. Pratama, M., Yanfia, Y., & Nusantara, P. D. (2023). Wizard of Math: A top-down puzzle game with RPG elements to hone the player's arithmetic skills. Procedia Computer Science, 216, 338–345.

Safitri, D., Awalia, S., Sekaringtyas, T., Nuraini, S., Lestari, I., Suntari, Y., Marini, A., Iskandar, R., & Sudrajat, A. (2022). Improvement of student learning motivation through word-wall-based digital game media. International Journal of Interactive Mobile Technologies, 16(06), 188–205.

Saripudin, D., Komalasari, K., & Anggraini, D. N. (2021). Value-based digital storytelling learning media to foster student character. International Journal of Instruction, 14(2), 369–384.

Sherryl, J. L. (2006). Matching computer game genres to educational outcomes. Electronic Journal of Communication, 16(1 & 2).

Shute, V. J., Ventura, M., Bauer, M. I., & Zapata-Rivera, D. (2009). Melding the power of serious games and embedded assessment to monitor and foster learning: Flow and grow. In U. Ritterfeld, M. J. Cody, & P. Vorderer (Eds.), Serious games: Mechanisms and effects (pp. 295–321). Routledge.

Sidhu, M. S., & Ying, J. G. (2017). Experiencing new learning, interaction and visualization process using augmented reality technology. TEM Journal, 6(2), 222–231.

Sudargo, Buchori, A., & Rahmawati, N. D. (2017). *Desain pengembangan digital math game dengan model etnomatematika pada mata kuliah matematika SMA.* Jurnal Karismatika.

Vastyanov, R., Yermuraki, P., Stoyanov, A., Tiron, O., Beseda, Y., Ostapenko, I., Dobrovolsky, V., Lapshin, D., & Stecenko, A. (2021). New aspects of pedagogical activity in the distant form of pathological physiology teaching to medical university students. Journal of Education, Health and Sport, 11(10), 173–186.

Vogel, J. J., Vogel, D., Cannon-Bowers, J., & Bowers, C. A. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. Journal of Educational Computing Research, 34(3), 229–243.

Wibawa, R., Lokacarya, A., Kurniawana, F., & Udjaja, Y. (2023). Japanese language learning game “Miryoku” using Android-based speech recognizer API. Procedia Computer Science, 216, 547–556.

Widyasari, W., Sutopo, H., & Agustian, M. (2019). QR code-based learning development: Accessing math game for children learning enhancement. International Journal of Interactive Mobile Technologies, 13(11), 111–124.