DOI: 10.14421/impulse.2025.51-03

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 5, Issue 1, 37 – 48

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

The Development of Android-Based Educational Games on Work and Energy Material to Train Critical Thinking Skills

Hanifah Ridho Syuwari*, Ari Cahya Mawardi

Physics Education Study Program, UIN Sunan Kalijaga Yogyakarta, Indonesia
*Corresponding author: hanifahridhos@gmail.com

ABSTRACT

Critical thinking has emerged as an essential skill for students to master in the 21st century. The topic on work and energy is difficult for students, this is due to limitation in learning media in terms of helping students, especially those based on technology. This study aimed to investigate: 1) The features of Android-based educational games designed to enhance critical thinking skills among eighth-grade students of SMP/MTS, 2) The quality of the Android-based educational games in achieving the critical thinking skills train on work and energy topic among eighth-grade students of SMP/MTS, 3) Students' perceptions of Android-based educational game on the topic of work and energy to train the critical thinking skills among eighth-grade students of SMP/MTS, 4) Enhancement of critical thinking skills among eighth-grade SMP/MTS students. This research applied a 4D model of Research and Development (R&D) that was restricted to the development stage. The research employed instruments for experts, teachers, and students. The data analysis involved V Aiken's validation, mean calculations, and N-Gain. The results of this study included: 1) the creation of learning media in the form of an educational game named GEDUSI (Energy and Work Education Games), 2) The quality of the education game developed by researchers is included in the Very Good category, 3) Student responses agree as a practical and fun learning media, 4) This game can improve students' critical thinking skills.

INTISARI

Berpikir kritis telah menjadi keterampilan penting yang harus dikuasai oleh siswa di abad ke-21. Materi tentang usaha dan energi sulit bagi siswa, Ini disebabkan oleh terbatasnya media pembelajaran yang dapat mendukung siswa, khususnya yang berbasis teknologi. Penelitian ini bertujuan untuk mengetahui 1) Karakteristik permainan edukasi berbasis Android pada topik usaha dan energi untuk melatih keterampilan berpikir kritis siswa kelas VIII SMP/MTS, 2) Kualitas permainan edukasi berbasis Android pada topik usaha dan energi dalam melatih keterampilan berpikir kritis kelas VIII SMP/MTS, 3) Respon siswa terhadap permainan edukasi berbasis Android pada topik usaha dan energi dalam mengembangkan keterampilan berpikir kritis siswa kelas VIII SMP/MTS, 4) Perkembangan keterampilan berpikir kritis kelas VIII SMP/MTS. Penelitian ini menggunakan model Penelitian dan Pengembangan (R&D) 4D yang terbatas pada tahap pengembangan. Instrumen penelitian yang digunakan

ARTICLE HISTORY
Received: January 31, 2025
Accepted: September 25, 2025

KEYWORDS:
Critical Thinking, Educational Games, Work and Energy.

KATA KUNCI:
Berpikir Kritis, Game Edukasi, Usaha dan Energi.

* Corresponding author:
Hanifah Ridho Syuwari, Physics Education Study Program, UIN Sunan Kalijaga Yogyakarta, Indonesia
✉ hanifahridhos@gmail.com

terdiri atas instrumen untuk ahli, instrumen untuk guru, dan instrumen untuk siswa. Analisis data yang digunakan adalah validasi V Aiken, rata-rata, dan N-Gain. Temuan dari penelitian ini ialah 1) Pengembangan media pembelajaran berupa permainan edukasi yang disebut GEDUSI (Game Edukasi Energi dan Usaha), 2) Kualitas permainan edukasi yang diperoleh oleh peneliti termasuk dalam kategori Sangat Baik, 3) Tanggapan siswa setuju bahwa media pembelajaran ini praktis dan menyenangkan, 4) Permainan ini dapat meningkatkan keterampilan berpikir kritis siswa.

A. Introduction

Critical thinking has become one of the skills that students must possess in facing the millennium era and the 4.0 industrial revolution. This is because critical thinking skills not only help students overcome various challenges but also enable them to express innovative ideas in various contexts [1]. Critical thinking skills are highly needed in learning, especially in studying natural sciences regarding phenomena and natural interactions that occur in life, such as physics[2]. Designing learning experiences that genuinely foster critical thinking requires an understanding of how students process ideas and how those ideas connect with the conceptual structures they are expected to grasp. In physics education, this becomes particularly essential, as students are often required to interpret physical phenomena not just in terms of what happens, but through careful reasoning about how and why those events unfold by Ilma & Kuswanto [3]. However, physics is still considered difficult by students due to the numerous equations and abstract concepts. One of the physics topics that students find difficult to understand is work and energy[4].

Work and energy are among the subjects that difficult to understand because they are related to other concepts. Understanding these concepts involves observation, analysis, and data interpretation, thus requiring critical thinking skills[5]. For students, this concept is difficult because it relates to natural phenomena in a sequential, meaningful manner, and its application complicates students' understanding and ability to answer related questions [6]. The connection between daily life and the material of work and energy is very close because it explains the principles of work and energy, various types of energy, and the relationship between work and energy in daily activities..

Based on the results of observations at one of the MTS in Sleman Regency, it shows that students are still lacking in precision in calculations using the correct equations to solve work and energy phenomenon problems. This is caused by students' lack of enthusiasm in enjoying the learning process and the stages of learning that have not yet supported the improvement of students' critical thinking skills, among other things, students are only given information but are not taught to conclude and analyze information critically[7].

.

Similar patterns have been described in previous studies, including one by Yuliati et al. [8] which found that science learning in many Indonesian junior high schools tends to focus more on content delivery than on guiding students to reason independently. As a result, students often follow explanations passively without being encouraged to examine relationships between concepts or explore different ways to solve a problem. These findings are also reflected in the results of the 2018 PISA assessment where Indonesian students scored an average of 383 in science, far below the OECD average of 485[8]. The biggest gaps in performance were seen in questions that asked students to understand scientific information or make sense of data. These are the kinds of tasks that can be handled better if students are used to thinking carefully and drawing conclusions during lessons.

Teacher interviews revealed that students still struggle to understand the concepts of work and energy, particularly in explaining work and energy activities in daily life, analyzing equations in work and energy problems, and providing and considering conclusions about work and energy. This causes students to become less enthusiastic, appear boring, and not challenging, causing them to have less enjoyment in the learning process[9]. Furthermore, the existing learning media used have limitations, especially in terms of helping students understand technology-based work and energy materials.

This condition shows the need for learning media that can offer more than just content delivery. It should be able to create space for students to explore ideas, reflect, and connect what they learn with everyday experience. One form of such media is the educational game designed for Android. Android-based games have become increasingly relevant to students' learning environments because they are accessible, portable, and familiar. These games provide opportunities for realtime interaction and immediate feedback, which are essential for training cognitive processes such as analysis and decision making. Moreover, the game structure through features like progression, scoring, visual representation, and problem scenarios can be designed to help students recognize patterns and test conclusions based on evidence.

Several studies in physics education have shown that educational games are effective in helping students develop the ability to think clearly and logically. Af'idah & Kustijono [10] found that the game based learning media they designed was suitable for use in class and supported students in understanding scientific ideas through structured problem solving. The media passed expert validation with strong results and its application in learning gave students the chance to practice analyzing questions and drawing conclusions. Novidya & Kustijono [11] also reported that physics games helped students approach problems with more attention to reasoning. The game guided them to trace how different ideas are connected while also giving space to try out problem solving strategies in a more interactive way. Rather than simply receiving information, students were encouraged to stay engaged and think through each challenge as they progressed through the material.

Based on the discussion above, learning media can be one of the solutions in facilitating the understanding of work and energy material. When that media includes critical thinking elements such as problem analysis and decision making tasks, it becomes a powerful support for content mastery and for deeper cognitive growth. Games can serve as a learning medium that can develop and assess students' critical thinking skills, because while playing games, students can analyze problems, identify relationships between the given questions, and use the appropriate steps when solving problems[12].

However, many existing studies still focus on either the design of the games or their general effects on student learning. Few explore how the internal structure of a game can be directly aligned with specific critical thinking indicators in physics. Therefore, it is necessary to develop more innovative and interactive media. Learning media that incorporates elements of critical thinking such as educational games have become an important learning media in enhancing students' ability of critical thinking skills and facilitating their comprehension of the material.

Based on these considerations, this research was conducted with the title "Development of Android-Based Educational Games on Work and Energy Material to Train Critical Thinking Skills of Eighth Grade Junior High School/Islamic Junior High School Students." The novelty of this research lies in how the content of the game is not only focused on delivering material but is designed to reflect indicators of critical thinking such as identifying problems, evaluating relationships, and drawing conclusions within the topic of work and energy.

B. Method

This research applied a development research approach, also referred to as Research and Development (R&D) 4D model was created by Thiagarajan in 1974. The 4D model includes four stages which are define, design, development, and disseminate[9]. In this study, the product development stage is limited to the development phase, specifically product testing.

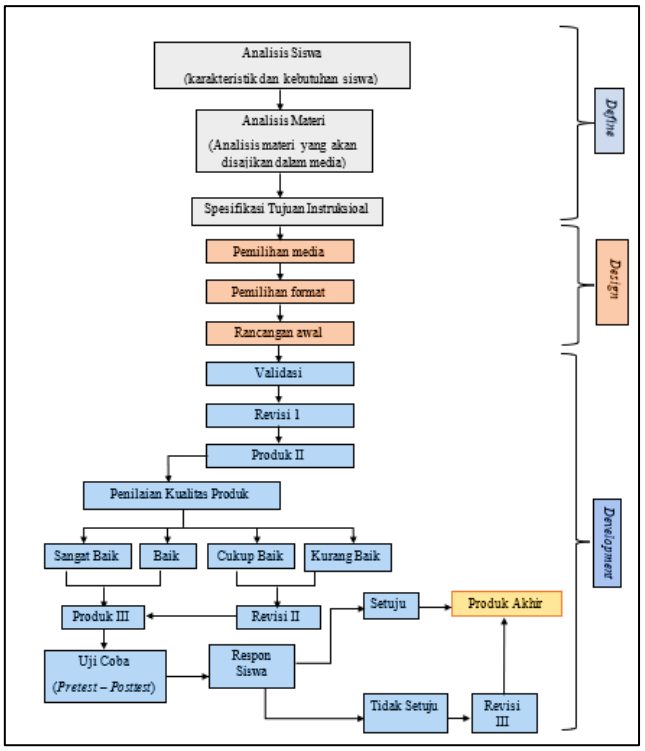

Figure 1. Stages of the Media Development Procedure

The researchers utilized both test and non-test instruments, including validation forms, product evaluation forms, assessment forms, and student feedback sheets. Qualitative data in this study consist of feedback and recommendations from validation and assessment outcomes, including those from experts in the subject matter, media, and science teachers). Quantitative data includes the assessment results from experts and teachers, student responses, and pretest-posttest results[13].

The data analysis conducted includes both qualitative and quantitative methods. Descriptive qualitative data analysis is a description of the results of expert input and suggestions. Quantitative data analysis determines the quality of the developed product by processing data based on expert evaluations, teacher assessments, and student responses[14]. Additionally, there is also a pretest-posttest to observe the improvement in students' critical thinking skills.

Product feasibility is evaluated using a Likert scale ranging from one to four. The final score is obtained from the average result of each evaluated aspect, using the following equation[15].

$$\bar{X} = \frac{\sum x}{N.n} \quad (1)$$

$\bar{X}$: Average score
$\sum x$: Total score obtained
N : Number of evaluators

n : Number of questions

Table 1. Media Assessment Criteria Categories

Avarage Score ($\bar{X}$)	Category
$3.25 < \bar{X} \leq 4.00$	Very Good (VG)
$2.50 < \bar{X} \leq 3.25$	Good (G)
$1.75 < \bar{X} \leq 2.50$	Not Good (NG)
$1.00 < \bar{X} \leq 1.75$	Very Not Good (VNG)

Analysis of student responses uses data analysis techniques to convert quantitative data into qualitative data. Data obtained from the questionnaire with a Guttman scale of 0-1 was then converted into an average score.

Table 2. Criteria for Student Response Categories

Avarage Score	Category
$0.5 < \bar{X} \leq 1.0$	Agree (A)
$0.0 < \bar{X} \leq 0.5$	Disagree (D)

The pretest and posttest results were then computed using the N-Gain standard. The calculation can be performed using the N-Gain test equation.

$$(g) = \frac{(S_f)-(S_i)}{(S_m)-(S_i)} \quad (2)$$

With (g) is the gain score, (S_m) is the highest score, (S_i) is the pretest score, and (S_f) is the posttest score. The results of the calculation were interpreted using the N-Gain criteria in Table 3 [16].

Table 3. N-Gain Criteria

Avarage Score	Category
$(g) \geq 0.7$	High
$0.3 \leq (g) < 0.7$	Medium
$(g) < 0.3$	Low

C. Result and Discussion

Product Development

This research produces a product in the form of an Android-based educational game that assists students in practicing critical thinking skills related to work and energy materials. The educational game was developed using Smart Apps Creator which is a visual programming platform designed specifically for building Android applications in a more accessible way. This platform was chosen because it allows

developers to arrange logical functions and visual components through a block-based system, so that the structure of the game can be built without requiring text-based coding. In addition to its simplicity, the platform also provides features for integrating images, animations, and sound which makes it easier to present learning content in ways that are more engaging and easier to understand. These characteristics support the development of learning media that not only deliver content, but also encourage students to interact with the material more actively.

The 4D development model includes four stages which are define, design, development, and disseminate, also is limited to the improvement stage based on the basic formulation of this research, which only examines the trial results[9]. The definition stage is the first phase of the research, focusing on conducting a needs analysis. The researcher conducted three stages of needs analysis, namely student analysis, material analysis, and goal analysis resulting from observations and interviews.

The second stage is the design stage, aimed at determining the product concept to be developed according to the students' needs after conducting observations and interviews. In this stage, there are 4 types of activities carried out, such as product selection, game concept design, material and evaluation tool design, and game design. The selection of the product is the result of an analysis of student needs and material characteristics, thereby creating a practical and efficient medium. The conceptual design for the creation of this educational game begins with mapping the content that will become the characteristic in the presentation of the educational game. The content consists of work and energy materials presented in the form of animated videos. In addition, there are evaluation questions formulated from four of Ennis's critical thinking indicators, which can measure the level of students' critical thinking abilities [17]. Next, for the product design stage, the researcher designed an interesting and enjoyable game using several software, resulting in an Android application with several components. The components of this game application include the home page, main menu, game rules, information, materials, play, game levels, and total score. The third stage is the development stage, which inludes two phases: expert evaluation and product testing. The development stage intends to assess the feasibility and response of the product that has been developed.

Validation and Product Assessment

Product validation is performed by material and media experts who provide assessments based on the Valid Without Revision (VWR), Valid With Revision (VR), and Invalid (I), as well as giving feedback on the product. The following presents the results of the product validation conducted by content and media experts.

Table 4. Material and Media Expert Validation Results

Validator	Aspect	Criteria
Material Expert	Contents	Valid With Revision
	Language	Valid With Revision
	Display	Valid With Revision
Media Expert	Usage	Valid With Revision
	Instructional	Valid With Revision
	Critical Thinking	Valid With Revision

Referring to the product validation table carried out by two validators, it indicates that the designed product meets the criteria of Valid With Revision (VR), indicating that the product can be used after undergoing a revision stage based on input or suggestions from the validators.

Product assessment involves evaluation by product experts (material and media) and science teachers, using a Likert scale with assessment categories: Very Good (VG), Good (G), Fair (F), and Poor (P). Here are the results of the assessment by subject matter experts, media experts, and teacher evaluations.

Table 6. Material Expert, Media Expert, and Teacher Assessment

Validator/Respondent	Aspect	Average Score	Criteria
Material Expert	Content of the material	3.75	Very Good
	Language	3.00	Good
Media Expert	Display	3.75	Very Good
	Usage	3.67	Very Good
	Instructional	4.00	Very Good
	Critical Thinking	4.00	Very Good
Teacher	Content of the material	4.00	Very Good
	Language	4.00	Very Good
	Display	4.00	Very Good
	Usage	3.67	Very Good
	Instructional	4.00	Very Good
	Critical Thinking	4.00	Very Good

The average score data from the validation results provide a clearer picture of how the product is perceived in terms of its quality and relevance to learning. According to the material expert, the content component was considered strong although the language still needs improvement in terms of clarity and coherence. Meanwhile, the media expert noted that the product was well-designed in its structure, especially in parts that aim to stimulate critical thinking. These two aspects namely instructional design and cognitive depth were rated very highly which indicates that the game successfully aligns its features with meaningful learning goals.

The teacher's responses has the similar opinions. From content and appearance to functionality and support for thinking skills, every aspect received positive evaluations. These findings indicates that the educational game offers not only a visually appealing platform but also an experience that helps students practice thinking carefully and making sense of what they learn. Although some improvements may still be required in the wording and user instructions, the overall product has shown promise as a tool for both delivering content and encouraging students to think more critically as they interact with each task.

Product Testing

The product trial in this research consists of two steps: a limited trial and an extensive trial. Here are the results of the limited and extensive trials in the form of a comparison of pretest-posttest critical thinking abilities for each aspect, N-Gain results, and response tests from 30 students.

Table 7. Student Response Results in the Limited Trial of the Educational Game

Aspect	Average Score	Criteria
Content of the material	1.00	Agree
Language	1.00	Agree
Display	0.83	Agree
Usage	0.83	Agree
Instructional	1.00	Agree
Critical Thinking	1.00	Agree

Based on the results of the limited trial, students responded positively to the educational game in almost every aspect. The component related to content was rated with the highest average score and similar responses were given for language, instructional clarity, and the extent to which the game supported critical thinking. Each of these areas reached an average score of 1.00 which reflects a high level of alignment between the media and what students found useful in their learning experience. On the other hand, the display and usability aspects received slightly lower scores with each of them has the average number of 0.83. Even though these aspects were still considered effective, the scores indicate that the visual layout and technical handling may not have been as impactful as the other components in the students' perception.

Table 8. Student Response Results in the Extensive Trial of the Educational Game

Aspect	Average Score	Criteria
Content of the material	0.90	Agree
Language	0.90	Agree
Display	0.83	Agree
Usage	0.83	Agree
Instructional	0.90	Agree
Critical Thinking	0.85	Agree

The extensive trial was conducted after making several improvements to the media based on earlier feedback. In this broader test, the students continued to give high scores in most categories. The content, the clarity of language used, and the structure of instruction were each rated at an average of 0.90. These results indicate that the revisions had preserved the key qualities students valued in the limited trial. The visual design and ease of use still held steady at 0.83 which shows consistency in how students navigated and interacted with the game, although these features may have remained less noticeable. For the critical thinking aspect, the score reached 0.85 which reflects that the game provided opportunities for students to engage with challenges that required thoughtful analysis and reflection during the learning process.

The students' response to the developed product showed a positive response with an average score of 0.94 for the limited trial and an average of 0.93 for the extensive trial. In addition to aiming to determine student responses, this product is also tested to determine the extent of students' critical thinking skills before and after using the media. The table above shows the comparison of the average pretest and posttest scores for each aspect of critical thinking, along with the N-gain test results.

Table 9. Comparison of Average Pretest and Posttest Critical Thinking Skills of Students by Aspect

Aspect	Pretest	Posttest	N-Gain	Improvement
Focusing the question	75.2	86.6	0.46	11.4
Asking and answering a question about an explanation	37.2	80.0	0.68	42.8
Analyzing the question	48.0	94.6	0.90	46.6
Considering the relevance of the source	5.2	29.4	0.26	24.2

Table 10. N-Gain Test Results

Number of Students	Average Pretest	Average Posttest	Average N-Gain	Category
30	60.8	82.6	0.56	Medium

According to the results of the pretest and posttest, the comparison of each aspect of students' critical thinking skills is known. It is known that the greatest improvement in the average pretest and posttest scores is found in the aspect of analyzing questions, with an average score of 2.33. On the other hand, the smallest increase in the average pretest and posttest scores was observed in the aspect of focusing on the problem, with an average of 0.57. In addition, the enhancement of students' critical thinking skills can also be achieved through N-Gain analysis. The average pretest and posttest scores obtained a gain value of 0.56, categorized as moderate. Therefore, it can be concluded that there was an enhancement in students' critical thinking skills after using the educational game.

D. Conclusion

This research resulted in a learning media with the characteristic that this application can train critical thinking skills through an interactive and enjoyable approach, as well as presenting effort and energy material accompanied by evaluation questions with four critical thinking indicators. This game proved to have Very Good quality based on the assessment of material experts, media experts, and teachers. This game also received positive feedback from students, with a high level of agreement in both the limited and extensive trials. Moreover, this application proves to be successful in improving students' critical thinking abilities, making this game a worthy and beneficial learning medium for training students' critical thinking abilities.

References

[1] P. Partono, H. N. Wardhani, N. I. Setyowati, A. Tsalitsa, and S. N. Putri, "Strategi Meningkatkan Kompetensi 4C (Critical Thinking, Creativity, Communication, & Collaborative)," *J. Penelit. Ilmu Pendidik.*, vol. 14, no. 1, pp. 41–52, 2021, doi: 10.21831/jpipfip.v14i1.35810.

[2] N. Asnawi, A. Indika Seprapti, A. Haqqo, A. Lailaul Fitriyah, S. Kusairi, and P. Parno, "Pemahaman Konsep Dan Kesulitan Belajar Mahasiswa: Studi Lintas Semester Pada Materi Usaha Energi," *J. Ilm. Pendidik. Lingkung. dan Pembang.*, vol. 21, no. 01, pp. 18–29, 2020, doi: 10.21009/plpb.211.03.

[3] A. Z. Ilma and H. Kuswanto, "Gravitational Acceleration: Its Determination from Gourami Jumping Motion Using Tracker Application," *Impuls. J. Res. Innov. Phys. Educ.*, vol. 4, no. 2, pp. 96–106, 2025, doi: 10.14421/impulse.2024.42-03.

[4] E. Septianawati and E. Abdilah, "Kemampuan Penalaran Matematis Ditinjau dari Model Problem Based Learning dengan Contextual Teaching and Learning,"

KontinuJurnal Penelit. Didakt. Mat., vol. 5, no. 2, pp. 80–87, 2021, doi: 10.30659/kontinu.5.2.80-87.
[5] S. Damarjati and A. Miatun, "Pengembangan Game Edukasi Berbasis Android sebagai Media Pembelajaran Berorientasi pada Kemampuan Berpikir Kritis," *ANARGYA J. Ilm. Pendidik. Mat.*, vol. 4, no. 2, pp. 164–175, 2021, doi: 10.24176/anargya.v4i2.6442.
[6] A. I. Seprapti, Nizami, A. Haqqo, A. L. Fitriyah, S. Kusairi, and Parno, "Pemahaman Konsep dan Kesulitan Belajar Mahasiswa: Studi Lintas Semester pada Materi Usaha Energi," *J. Ilm. Pendidik. Lingkung. dan Pembang.*, vol. 21, no. 01, pp. 18–29, 2020, doi: 10.21009/plpb.211.03.
[7] A. A. Permana and I. Kartika, "Brain-Based Learning: The Impact on Student's Higher Order Thinking Skills and Motivation," *J. Ilm. Pendidik. Fis. Al-Biruni*, vol. 10, no. 1, pp. 47–58, 2021, doi: 10.24042/jipfalbiruni.v10i1.6908.
[8] L. Yuliati, R. Fauziah, and A. Hidayat, "Student's Critical Thinking Skills in Authentic Problem based Learning," in *Journal of Physics: Conference Series*, Bandung: IOP Publishing, 2018, pp. 1–6. doi: 10.1088/1742-6596/1013/1/012025.
[9] N. Jalinus *et al.*, "Developing Blended Learning Model in Vocational Education Based On 21st Century Integrated Learning and Industrial Revolution 4.0," *Turkish J. Comput. Math. Educ.*, vol. 12, no. 9, pp. 1276–1291, 2021.
[10] I. Af'idah and R. Kustijono, "Penggunaan Physics Education Game untuk Melatihkan Keterampilan Berpikir Kritis Siswa SMA," *IPF Inov. Pendidik. Fis.*, vol. 9, no. 1, pp. 271–275, 2020.
[11] S. D. Novidya and R. Kustijono, "Game Applied Physics untuk Melatihkan Keterampilan Berpikir Kritis Siswa SMA," *IPF Inov. Pendidik. Fis.*, vol. 09, no. 02, pp. 242–246, 2020.
[12] T. S. Qodr, "Pengembangan Mobile Game-based Learning pada Mata Pelajaran Sosiologi untuk Meningkatkan Keterampilan Berpikir Kritis pada Siswa SMA di Klaten," UNS, 2022.
[13] O. P. Aryaningtyas, "Pengembangan Media Game Edukasi Matematika Materi Penjumlahan untuk Kelas I SD/MI," UIN Sunan Kalijaga Yogyakarta, 2023.
[14] Sugiyono, *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D*. 2020.
[15] F. A. Zahwa and I. Syafi'i, "Pemilihan Pengembangan Media Pembelajaran Berbasis Teknologi Informasi," *Equilib. J. Penelit. Pendidik. dan Ekon.*, vol. 19, no. 01, pp. 61–78, 2022, doi: 10.25134/equi.v19i01.3963.
[16] M. Fishburne, "Amanda," *Who We Are Now*, vol. VIII, no. 1, pp. 210–213, 2024, doi: 10.5149/northcarolina/9781469671239.003.0098.
[17] D. Sulisworo, "Blended Learning: Improving Student's Motivation in English Teaching Learning Process," *Int. J. Lang. Educ.*, vol. 1, pp. 163–170, Mar. 2018, doi: 10.18298/ijlet.2434.

.