



## GAME-BASED LEARNING MEDIA: EFFORT TO INCREASE SELF-REGULATED LEARNING AND CRITICAL THINKING SKILLS IN SCIENCE

Ria Rochmi Safitri<sup>1</sup> & Eko Marwanto<sup>2</sup>

<sup>1</sup>Sekolah Menengah Pertama Negeri 1 Sampit, Kalimantan Tengah, Indonesia

<sup>2</sup>Sekolah Menengah Kejuruan Negeri 2 Sampit, Kalimantan Tengah, Indonesia

<sup>1</sup>Contributor Email: [riasafitri34@guru.smp.belajar.id](mailto:riasafitri34@guru.smp.belajar.id)

Received: September 4, 2025

Accepted: October 22, 2025

Published: November 30, 2025

Article Url: <https://ojsdikdas.kemendikdasmen.go.id/index.php/didaktika/article/view/2021>

### Abstract

*Low levels of self-regulated learning and critical thinking skills among students remain a challenge in science education, as teacher-centred approaches still dominate learning activities. This study aims to develop, examine the practicality, and test the effectiveness of game-based learning (GBL) media in enhancing students' self-regulated learning and critical thinking skills. This research employed a research and development (R&D) design using Rido Ramadan's version of the Game Development Life Cycle (GDLC) model, consisting of six stages: initiation, pre-production, production, testing, beta, and release. Data were collected through both test and non-test techniques at SMP Negeri 1 Sampit, involving teachers and grade VII students using a randomized pretest-posttest control group design. The results show that GBL media is feasible in both construction and content with "very good" criteria, practical based on teacher and student responses, and effective in improving self-regulated learning (N-gain = 0.10) and critical thinking skills (N-gain = 0.50), compared to PowerPoint-based learning. In conclusion, the developed GBL media is valid, practical, and effective as an innovative learning tool to promote independent and critical learning in science education.*

**Keywords:** *Game-based Learning; Self-regulated Learning; Critical Thinking Skills; Science Education.*

---

## **Abstrak**

*Rendahnya tingkat pembelajaran mandiri dan keterampilan berpikir kritis di kalangan siswa menjadi tantangan utama dalam pendidikan sains yang karena kegiatan pembelajaran masih berpusat pada guru. Penelitian ini bertujuan untuk mengembangkan, menguji kepraktisan, dan menguji efektivitas media pembelajaran berbasis permainan (GBL) dalam meningkatkan pembelajaran mandiri dan keterampilan berpikir kritis siswa. Penelitian ini menggunakan desain penelitian dan pengembangan (R&D) menggunakan model Siklus Hidup Pengembangan Permainan (GDLC) versi Rido Ramadan, yang terdiri dari enam tahap, yaitu: inisiasi, praproduksi, produksi, pengujian, beta, dan rilis. Data dikumpulkan melalui teknik tes dan non-tes di SMP Negeri 1 Sampit, yang melibatkan guru dan siswa kelas VII dengan menggunakan desain kelompok kontrol pretes-postes acak. Hasil penelitian menunjukkan bahwa media GBL layak dalam konstruksi dan konten dengan kriteria "sangat baik", praktis berdasarkan respons guru dan siswa, dan efektif dalam meningkatkan pembelajaran mandiri (N-gain = 0,10) dan keterampilan berpikir kritis (N-gain = 0,50), dibandingkan dengan pembelajaran berbasis PowerPoint. Kesimpulannya, media GBL yang dikembangkan valid, praktis, dan efektif sebagai alat pembelajaran inovatif untuk meningkatkan pembelajaran mandiri dan kritis dalam pendidikan sains.*

**Kata Kunci:** *Game-Based Learning; Kemandirian Belajar; Keterampilan Berpikir Kritis; Pembelajaran IPA.*

---

## **A. Introduction**

The development of science and technology demands that education systems equip students with essential twenty-first-century skills to enable them to compete and collaborate in a knowledge-based society. One of the crucial abilities that must be developed in this context is critical thinking, which allows learners to analyse, evaluate, and synthesise information for effective problem-solving and decision-making. However, research shows that Indonesian students' critical thinking skills remain relatively low (Hidayati et al., 2021; Jumaisyaroh et al., 2015; Saputri et al., 2018). In many classrooms, students still struggle to formulate logical arguments and evaluate evidence critically. Field observations also reveal that learning activities remain teacher-centred, where students primarily act as passive recipients rather than active participants in knowledge construction (Saputra et al., 2019). This situation occurs due to the limited implementation of instructional approaches that can stimulate analytical reasoning and reflective judgment (Ekaputra & Widarwati,

2023; Saputri et al., 2018). Consequently, students have few opportunities to engage in inquiry-based tasks or activities that train their higher-order thinking skills.

Another equally important issue in Indonesian education is the low level of students' self-regulated learning. This competency refers to the capacity of learners to take initiative, set goals, monitor their progress, and evaluate their performance in achieving learning objectives (Sulisworo & Sutadi, 2017). The ability to learn independently plays a decisive role in determining academic success and fostering long-term learning habits (Kolil et al., 2020). Nevertheless, various studies indicate that most students in Indonesia have not yet developed adequate self-regulation. They tend to depend heavily on teachers, follow instructions without initiative, and rarely attempt to explore alternative learning resources (Jumaisyaroh et al., 2015; Nurhidayanti et al., 2022; Pramana & Dewi, 2014). Moreover, students are not accustomed to selecting appropriate learning strategies, and they often hesitate when confronted with unfamiliar problems (Febriyanti & Imami, 2021; Jumaisyaroh et al., 2015). Learning materials and media such as modules and worksheets are often presented only as brief summaries, offering limited opportunities for students to deepen understanding or engage in independent exploration (Nurhidayanti et al., 2022; Pramana & Dewi, 2014). These conditions result in a passive learning culture, where students rely on external guidance rather than internal motivation to achieve learning goals.

Empirical evidence from preliminary studies conducted in several Indonesian junior high schools also supports this finding. Classroom observations and interviews reveal that students rarely initiate discussions or ask questions during lessons, and when they do, the questions tend to focus on factual "what" aspects rather than analytical "why" or procedural "how" aspects. Many students lack confidence when answering questions, struggle to explain reasoning, and depend on their peers when completing assignments. Teachers, meanwhile, still rarely utilise interactive or digital learning media that could foster student engagement. The absence of innovative and student-centred learning tools contributes to the persistence of conventional

practices, limiting opportunities for students to develop both autonomy and critical reasoning. This phenomenon indicates the urgent need for learning innovations that not only improve academic outcomes but also promote active participation and higher-order cognitive engagement.

The characteristics of today's learners, particularly those in middle schools aged 13 to 15 years, who belong to Generation Z, further underscore this need. This generation has grown up in a highly digital environment with unlimited access to information, rapid technological change, and the continuous emergence of new media trends (Suryanti et al., 2021). Consequently, traditional learning methods that rely solely on lectures and printed materials are no longer sufficient to engage their attention or accommodate their learning preferences. Educational innovations that integrate technology into the learning process are therefore essential to support motivation, inclusivity, and interactivity (Hendrastomo & Januarti, 2023). Technology in education not only serves as a medium for delivering content but also as a cognitive tool that facilitates meaningful learning experiences and nurtures independence, collaboration, and creativity among students (Meliani et al., 2022).

One promising approach that aligns with these demands is the use of *Game-Based Learning* (GBL). GBL is a learning model that integrates educational objectives into game mechanics, creating a dynamic and interactive environment in which learners engage through exploration, competition, and feedback. Games provide an immersive experience that helps students stay focused, fosters intrinsic motivation, and encourages them to think strategically to solve problems (Lampropoulos, 2023; Setyawan, Sulthoni, & Ulfa, 2019). GBL environments can transform learning into a more enjoyable and meaningful process by providing immediate feedback and adaptive challenges, allowing students to learn at their own pace (Bakhsh et al., 2022; Liu et al., 2020; Plass et al., 2020). Furthermore, GBL encourages self-regulation because students must plan actions, make decisions, and monitor progress to achieve objectives (Sabourin et al., 2012; Wan et al., 2021). This combination of cognitive and motivational stimulation enables learners to develop both

independence and analytical thinking, making GBL particularly suitable for improving self-regulated learning and critical thinking skills simultaneously.

Previous research supports the potential of GBL in promoting learning effectiveness and student engagement. Safitri et al. (2025), through a systematic review, concluded that GBL significantly enhances various competencies, including independent learning and critical thinking skills, across science education contexts. Similarly, Syahri et al. (2014) found that *Digital Game-Based Learning Media* was highly feasible and effective for environmental pollution topics, as evidenced by students' high completion rates, intense interest, and active participation. Chen and Wu (2021) also reported that digital role-playing games contribute significantly to students' motivation and critical thinking abilities, while Rifki and Lutfi (2022) demonstrated that the "Chemistry Racing Challenge" game is valid, practical, and effective in fostering learning independence. Moreover, research by Mao et al. (2022) and Cicchino (2015) showed that interactive digital games improve critical reasoning through problem-solving and reflective decision-making processes. These findings indicate that the use of games in education does not merely serve entertainment purposes but functions as a pedagogical tool that integrates learning with engagement and self-regulation.

The effectiveness of GBL can also be explained through its theoretical foundation in cognitive and constructivist learning theories. According to Wu et al. (2012), game-based learning environments provide iterative learning cycles in which students actively test hypotheses, receive feedback, and adjust strategies. This process promotes metacognitive awareness and supports the development of critical and reflective thinking. Games encourage learners to take responsibility for their learning while simultaneously providing structured challenges that sustain motivation and persistence (Mayer, 2018). Plass et al. (2020) further argue that well-designed games combine instructional design, aesthetic appeal, and interactivity to create rich learning experiences that enhance both cognitive and affective outcomes. These theoretical perspectives reinforce the rationale for developing GBL media as a pedagogical

innovation that can respond to the dual challenges of low self-regulated learning and limited critical thinking skills among Indonesian students.

Based on these problems and theoretical considerations, this research was conducted to develop *Game-Based Learning* (GBL) media for science education that is valid, practical, and effective in supporting students' independent learning and critical thinking development. The study aimed to design a feasible digital game medium suitable for science learning, test its practicality based on teacher and student responses, and evaluate its effectiveness in improving self-regulated learning and critical thinking performance. Through this research and development project, it is expected that GBL media can become an innovative educational tool that integrates technological advancement with pedagogical needs, ultimately contributing to more engaging, reflective, and student-centred science learning in Indonesia.

**B. Method**

The research is classified as a type of Research and Development (R&D). The development model used is the Game Development Life Cycle (GDLC) version of Rido Ramadan, developed by Ramadan & Widyani (2013). This development model is a modification of the previously developed GDLC models. The development model consists of 6 stages, namely initiation, pre-production, production, testing, beta, and release. A summary of these stages is presented in Figure 1.

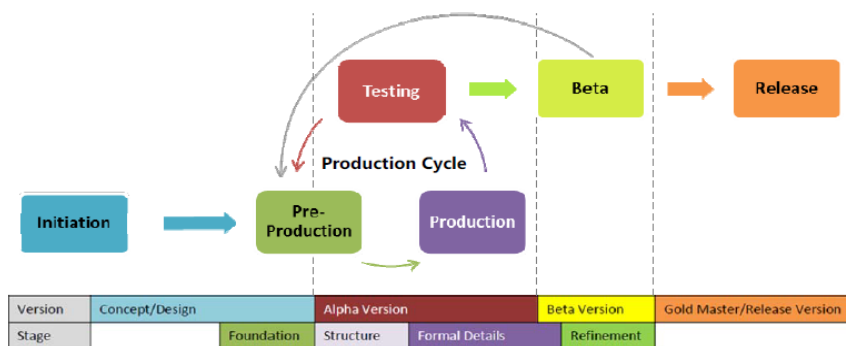


Figure 1. Rido Ramadan's Version of the GDLC Model

The initiation stage is carried out by designing the basic concept of the game and a brief description of the game that has been adjusted to the needs of the user. The analysis takes into account students' needs, learning materials, and technological aspects. The pre-production stage involves designing and refining the game concept as well as developing a prototype model. At this stage, a Game Design Document (GDD) is developed, which includes the storyline and characters, game missions, flowcharts, and storyboards. Production is the core stage that involves creating assets, coding sources, and combining the two elements. At this stage, a product is produced in the form of GBL media. The testing stage is a test by two experts related to the media or design of the model/ product and materials/content. The results at this stage are in the form of a statement regarding the suitability of GBL media for use in science learning. The beta stage is the product trial stage. At this stage, testing is carried out by a third/external party with the results in the form of bug reports and feedback from users while assessing practicality and readability, which is carried out through limited trials, and effectiveness, which is carried out through operational trials. The release stage is the final stage which includes the launch of the product and the dissection of the GBL media product that has been developed.

The product trial was conducted at SMP Negeri 1 Sampit. It consisted of preliminary field testing and operational field testing. The preliminary field testing was conducted to determine the respondent's response to the GBL media developed. This testing was carried out through playtesting by teachers and students. The subjects of the preliminary field testing were three science teachers who assessed the practicality of the GBL media and nine seventh-grade students with high, medium, and low cognitive abilities who assessed the readability of the GBL media. The operational field testing was conducted to determine the effectiveness of the product developed when compared to other products. The subjects of the operational field testing consisted of 74 students from the control and experimental groups. The determination of the control and experimental groups was carried out using a simple random system using a lottery (cluster random sampling) from

classes that had the same initial abilities based on the results of the End of Semester Summative in the odd semester. The design used in the operational field testing was a quasi-experiment with a randomised pretest-posttest control group design, which is shown in Table 1.

*Table 1. Randomised Pretest-Posttest Control Group Design*

<b>Group</b>	<b>Pretest</b>	<b>Treatment</b>	<b>Posttest</b>
Experiment	O <sub>1</sub>	Xa	O <sub>2</sub>
Control	O <sub>3</sub>	Xb	O <sub>4</sub>

Description:

Xa = Problem-Based Learning Model + Game-Based Learning Media

Xb = Problem-Based Learning Model + PowerPoint Media

O<sub>1</sub>, O<sub>3</sub> = Self-Regulated Learning and Critical Thinking Skills Before Learning

O<sub>2</sub>, O<sub>4</sub> = Self-Regulated Learning and Critical Thinking Skills After Learning

The operational field testing produced data on the effectiveness of GBL media compared to other media, namely PowerPoint media, using N-gain to determine the differences in self-regulated learning and critical thinking skills in both groups. The N-gain test was conducted using the following formula (Hake, 1998).

$$N \text{ gain} = \frac{\text{posttest} - \text{pretest}}{\text{maximum} - \text{pretest}}$$

The techniques used to collect data in this research consist of tests and non-test techniques. The test technique is carried out using written exams, while the non-test technique involves literature reviews, observations, and a questionnaire. Data collection instruments used include learning device (teaching modules), validation sheets, GBL media validation sheets, GBL media practicality test questionnaires, GBL media readability test questionnaires, learning observation sheets, self-regulated learning observation sheets, self-regulated learning questionnaires, and critical thinking skills test questions. Before being used, the self-regulated learning questionnaire and critical thinking skills test questions were tested theoretically using the Content Validity Index (CVI) (Polit & Beck, 2006) and empirically using IteMan software. The results obtained from an instrument in the form of a self-regulated learning

questionnaire with 22 statement items, which were deemed valid and reliable, along with a critical thinking skills test consisting of 14 questions, were also found to be valid and reliable. Indicators of self-regulated learning used include taking the initiative to learn, planning learning strategies, implementing learning strategies, empowering existing abilities, evaluating learning outcomes, and appreciating one's work results. Meanwhile, the indicators applied to measure critical thinking skills consist of explaining, analysing, concluding, evaluating, and making decisions.

### **C. Results and Discussion**

After completing all stages of the Game Development Life Cycle (GDLC) model, the next phase focuses on presenting the outcomes of the development and testing processes. This section outlines the results of the feasibility assessment, practicality testing, and effectiveness analysis of the developed Game-Based Learning (GBL) media. The results are systematically presented according to the sequence of activities undertaken during the research and development process, starting from the initiation stage to the release stage. Each phase describes how the GBL media was refined and evaluated, including expert validation, teacher and student responses, as well as statistical analysis to determine its impact on students' self-regulated learning and critical thinking skills.

#### **1. Results**

The learning media developed in this study is Game-Based Learning media. The development was carried out using the GDLC model version of Rido Ramadan, with stages consisting of initiation, pre-production, production, testing, beta, and release.

##### ***a. Initiation***

Analysis of needs is carried out by considering three aspects, namely students, materials, and technology. In terms of students, independent character and critical thinking need to be improved, because the achievements of both were the lowest in 2022 and 2023, based on the results of the educational report in Kotawaringin Timur Regency. This is further supported

by the findings from observations and interviews at SMP Negeri 1 Sampit, which showed that students had a lack of self-confidence, dependence on friends, and difficulty explaining the reasons behind the facts. In terms of materials, junior high school students in the Merdeka Curriculum (Kurikulum Merdeka) are classified into phase D, where they apply conceptual understanding to solve problems in everyday life. Science education includes an understanding of science and process skills to apply this knowledge, with four main content areas: living things, substances and their properties, energy, and earth and space. This science learning achievement is related to the topic of the Earth's structure, which is divided into four subtopics, namely the structure of the Earth's layers, tectonic plates, earthquakes, and volcanoes. From the technological aspect, the learning process at SMP Negeri 1 Sampit is dominated by the use of textbooks and worksheets, with little application of learning media that can affect the effectiveness of learning. This study developed a quiz game-based GBL media using Unity software, which includes features/elements, namely game mechanics, visual aesthetic design, narrative design, incentive system, musical score, and content and skills (Plass et al., 2020). The game developed can be run on an Android smartphone via the BlueStacks application, using a laptop/ computer with the additional BlueStacks App Player application, but cannot be used on an iPhone.

### ***b. Pre-Production***

The pre-production is the stage of preparing the Game Design Document (GDD), which includes creating a storyline and characters, designing missions, designing storyboards, and designing flowcharts. The material developed is the Earth Structure material studied by seventh-grade junior high school students. The theme chosen for this development is the mission to save the Earth from attacks by aliens. This GBL media is entitled Mission to Save The Earth (MisSErth). When playing the game, students act as prospective Earth rescue agents who are undergoing training. This training is represented in the form of missions that contain challenges in the form of questions that must be completed by students. GBL media consists of

four missions, which are determined based on four subtopics in the Earth structure material. Each mission consists of six levels that are developed based on learning objectives.

**c. Production**

The production stage uses Unity software to build a game. GBL media development is carried out by paying attention to aspects that can facilitate self-regulated learning and critical thinking skills of students.

Eleven main parts of GBL media are developed, namely the opening title, identity, introduction, main menu, storyline, game rules, mission map, mission, badge, info, and profile. The following is an example of the display of several parts in GBL media presented in Figure 2.

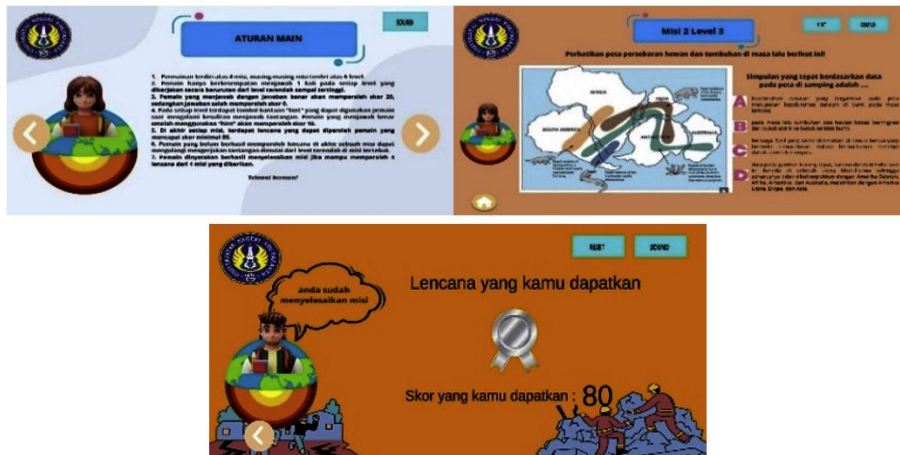


Figure 2. GBL Media View of the Rules, Missions, and Badges Section

**d. Testing**

The testing stage refers to the internal testing of formal details and game refinement. The testing stage involves two experts who test based on aspects of material/ content and media construction and provide improvements and input to the GBL media. The test results at this stage describe the feasibility of the GBL media. The results of the GBL media feasibility test from the two validators are presented in Table 2.

*Table 2. GBL Media Feasibility Test by Experts*

<b>Aspect</b>	<b>Average Score (X)</b>	<b>Criteria</b>
GBL Media Components	42	Very Good
Game Mechanics	4	Very Good
Visual Aesthetic Design	2.5	Very Good
Narrative Design	1	Very Good
Incentive System	1	Very Good
Musical Score	2	Very Good
Content dan Skills	8	Very Good
Overall	60.5	Very Good

Based on Table 2, the eligibility of GBL media is stated to be very good in all aspects, namely GBL media components with an average score of 42, game mechanics with an average score of 4, visual aesthetic design with an average score of 2.5, narrative design with an average score of 1, incentive system with an average score of 1, musical score with an average score of 2, and content and skills with an average score of 8. Overall, GBL media achieved an average score of 60.5, which falls under the very good category. Based on this, it can be interpreted that GBL media is stated to be feasible according to expert assessment.

#### **e. Beta**

In the beta stage, testing was conducted on the practicality, readability, and effectiveness of GBL media in learning. To examine its practicality, the GBL media was distributed to three teachers. The results of the teacher responses are shown in Table 3 below.

*Table 3. Practicality of GBL Media According to Teacher Assessment*

<b>Aspect</b>	<b>Average Score (X)</b>	<b>Criteria</b>
Suitability of Content and Presentation	5	Very Good
Suitability of Content with Aspects of Self-Regulated Learning	6	Very Good
Suitability of Content with Aspects of Critical Thinking Skills	5	Very Good
Language	5	Very Good
Graphics	5.67	Very Good
Game Control	4	Very Good

---

Overall	30.67	Very Good
---------	-------	-----------

---

Based on Table 3, GBL media is stated to be very good in all aspects, namely the suitability of content and presentation with an average score of 5, the suitability of content with aspects of self-regulated learning with an average score of 6, the suitability of content with aspects of critical thinking skills with an average score of 5, language with an average score of 5, graphics with an average score of 5.67, and game control with an average score of 4. Overall, The GBL media was rated as very good, achieving an average score of 30.67.

In addition to being assessed by teachers, GBL media was also given to nine students who assessed the readability of the product. Student response results are displayed in Table 4 below.

*Table 4. GBL Media Readability According to Student Assessment*

<b>Aspect</b>	<b>Average Score (X)</b>	<b>Criteria</b>
Language	4.67	Very Good
Graphics	5.56	Good
Game Control	3.67	Very Good
Overall	13.89	Very Good

Based on Table 4, GBL media is stated to be very good in the language aspect, with an average score of 4.67, and game control, with an average score of 3.67. Meanwhile, GBL media is stated to be good in the graphic aspect, with an average score of 5.56. Overall, assessment results indicate that GBL media is considered very good, with an average score of 13.89.

Furthermore, the effectiveness of GBL media is evaluated by analysing the results of the achievement of the two variables, namely self-regulated learning and critical thinking skills. The effectiveness of GBL media on self-regulated learning is determined by comparing the results before and after learning in the control and the experimental groups. Table 5 below is the result of the achievement of self-regulated learning of students from each group.

Table 5. Comparison of Self-Regulated Learning Achievements in Each Group

Aspect	Control Group		Experiment Group	
	Before	After	Before	After
Average Score	58.42	58.96	63.77	70.00
Highest Score	86.36	86.36	81.82	90.91
Lowest Score	22.73	27.27	31.82	36.36

Table 5 shows a comparison of self-regulated learning achievements in each group. In the control group, scores improved from 58.42 to 58.96. Meanwhile, in the experimental group, there was an improvement in the score, rising from 63.77 to 70.00. In general, the experimental group showed a greater increase in average scores compared to the control group. This increase can also be observed from the comparison of the n-gain of the two groups, which is presented in Figure 3.

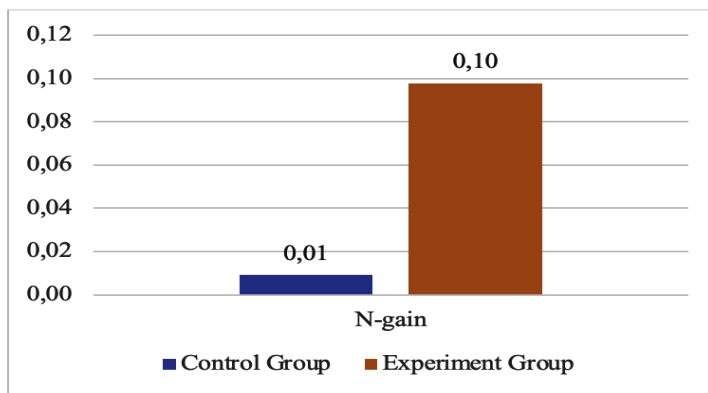


Figure 3. Comparison of N-Gain Self-Regulated Learning of Control and Experimental Group

Figure 3 shows the average n-gain score of self-regulated learning in the control group is 0.01. The n-gain obtained in this case is less than that of the experimental group, which recorded a score of 0.10. This indicates that self-regulated learning showed a more significant enhancement in the experimental group relative to the control group. Furthermore, analysis is also conducted on each indicator. Figure 4 illustrates the comparative analysis of self-regulated learning indicators before and after the learning process.

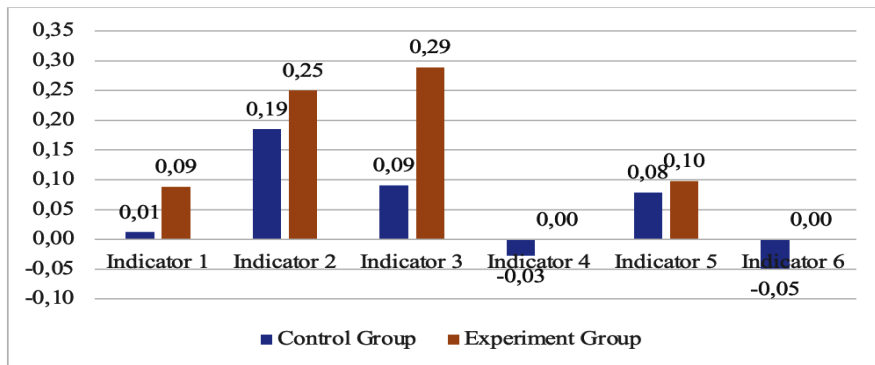


Figure 4. Comparison of N-Gain of Self-Regulated Learning of Each Indicator in the Control Group and Experimental Group

Figure 4 demonstrates that the experimental group achieved greater n-gain values than the control group on all self-regulated learning indicators. The meaning of these results is that learning using GBL media has a greater influence on increasing self-regulated learning than learning using PowerPoint.

In addition to using questionnaires, assessment of self-regulated learning was also carried out through observation activities by two observers in each class. Table 6 below shows the results of observations on each indicator.

Tabel 6. Self-Regulated Learning Observation Results

Indicator	Group	Meeting 1	Meeting 2	Meeting 3	Meeting 4	Average Score
1	Control	22.79	41.91	47.92	63.57	44.05
	Experiment	33.11	66.22	61.49	73.61	58.61
2	Control	11.76	38.24	34.72	38.57	30.82
	Experiment	20.27	64.86	58.11	73.61	54.21
3	Control	24.12	34.71	38.33	59.43	39.15
	Experiment	35.14	51.89	59.46	73.89	55.09
4	Control	24.79	39.08	40.87	53.47	39.55
	Experiment	40.54	49.03	62.55	74.60	56.68
5	Control	5.88	14.71	12.50	35.71	17.20
	Experiment	16.22	21.62	41.89	52.78	33.13
6	Control	29.41	47.06	65.28	71.43	53.29
	Experiment	31.08	55.41	67.57	80.56	58.65

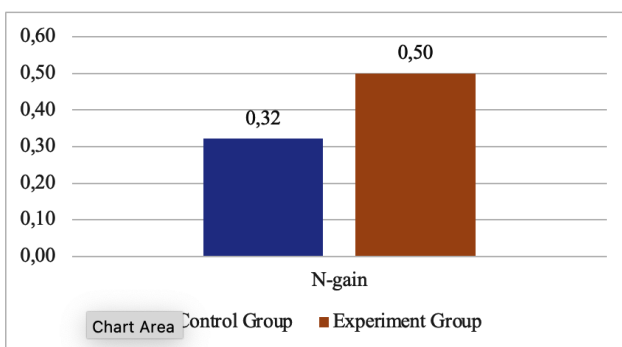
Table 6 reveals that the experimental group obtained higher average scores than the control group across all indicators. The observation results align with the questionnaire findings, which also indicate that the profile of student self-regulated learning is stronger in the experimental group compared to the control group.

Meanwhile, the effectiveness of GBL media in enhancing critical thinking skills was assessed by comparing pretest and posttest scores between the control and experimental groups. Table 7 below is the result of the achievement of students' critical thinking skills from each group.

*Table 7. Comparison of Critical Thinking Skills Achievement in Each Group*

Aspect	Control Group		Experiment	
	Pretest	Posttest	Pretest	Posttest
Average Score	29.41	38.87	39.80	62.86
Highest Score	57.14	85.71	64.29	92.86
Lowest Score	7.14	7.14	0.00	35.71

Table 7 shows a comparison of critical thinking skill achievement in each group. The control group showed an increase in scores from 29.41 to 38.87. Meanwhile, scores in the experimental group improved significantly, rising from 39.80 to 62.86. Overall, the data indicate that the experimental group showed a higher average score improvement than the control group. This increase can also be observed from the comparison of the n-gain of the two classes, which is presented in Figure 5.



*Figure 5. Comparison of N-Gain Critical Thinking Skills of Control Group and Experimental Group*

Figure 5 indicates that the control group's average n-gain score for critical thinking skills is 0.32. This value is lower when compared to the n-gain in the experimental group, which reached 0.50. It can be concluded that the experimental group showed a significantly greater increase in critical thinking skills than the control group.

Furthermore, an analysis was also conducted on each indicator. A comparison of n-gain values of each indicator in the control and experimental groups is shown in Figure 6.

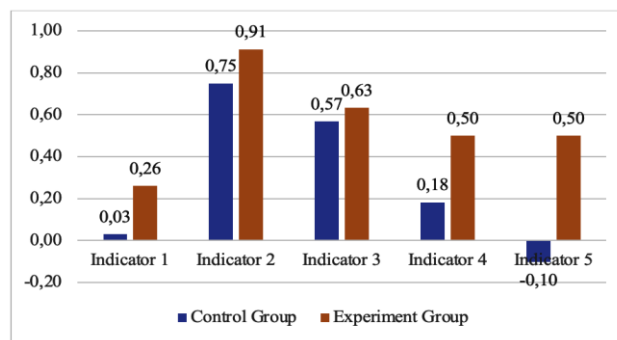


Figure 6. Comparison of N-Gain of Critical Thinking Skills of Each Indicator in the Control and Experimental Group

Figure 6 demonstrates that the experimental group obtained higher n-gain scores than the control group across all critical thinking skill indicators. The meaning of these results is that learning using GBL media has a greater influence on improving critical thinking skills than learning using PowerPoint.

#### *f. Release*

This stage is carried out through the distribution of GBL media to teachers and students of SMP Negeri 1 Sampit and several teachers in Kotawaringin Timur Regency. GBL media products are also registered for copyright as an effort to protect intellectual works

## **2. Discussion**

The results of this research demonstrate that the Game-Based Learning (GBL) media developed through the Game Development Life Cycle (GDLC)

model effectively enhances both self-regulated learning and critical thinking skills among junior high school students in science learning. This finding corresponds with the study's initial assumption that integrating interactive and problem-oriented digital games into science learning can stimulate learners' independence, motivation, and higher-order cognitive skills. The improvement of students' performance in the experimental group compared to the control group, as indicated by the N-gain scores of 0.10 for self-regulated learning and 0.50 for critical thinking, provides empirical evidence that the developed GBL media is not only feasible and practical but also pedagogically effective. These results align with previous findings emphasizing that GBL can transform passive learning environments into interactive spaces that foster analytical thinking, reflection, and self-directed learning (Lampropoulos, 2023; Plass et al., 2020; Capuno, 2023).

The GBL media was designed with six main game elements – game mechanics, visual aesthetic design, narrative design, incentive systems, musical scores, and content and skills (Plass et al., 2020) – which collectively contributed to its effectiveness. The inclusion of these elements allowed the media to address both cognitive and affective dimensions of learning. Through game mechanics that include explicit rules, missions, and challenges, students were encouraged to develop planning and strategic decision-making skills while solving contextual problems independently. The presence of hint buttons and the flexibility to access other sources encouraged exploration and reflection, allowing students to evaluate their choices and strategies. Such interactive feedback loops are consistent with the principles of self-regulated learning proposed by Zimmerman (2002), where students plan, monitor, and evaluate their learning in iterative cycles. The findings further strengthen the view that game mechanics serve as a practical framework for scaffolding students' metacognitive development by providing continuous feedback and adaptive challenges (Sabourin et al., 2012; Wan et al., 2021).

The visual aesthetic design and narrative structure of the developed GBL media also played significant roles in promoting student engagement and motivation. The appealing visual design and the mission-based storyline –

centred on the theme “*Mission to Save the Earth*” – created an immersive learning experience that captured students’ attention and sustained their curiosity. According to Mayer (2018), aesthetically engaging environments enhance learners’ intrinsic motivation and cognitive focus, especially when the design aligns with the learning objectives. The narrative element provided context and coherence to the game, allowing students to connect the learning content with meaningful experiences. This approach transforms abstract scientific concepts into relatable, story-driven challenges, which has been proven to support conceptual understanding and problem-solving (Chen & Wu, 2021; Hwang & Chang, 2020).

The incentive system in the form of scores, levels, and badges also contributed to fostering self-regulated learning and persistence. Rewards and feedback mechanisms reinforce learners’ sense of competence and autonomy, two key components of the *Self-Determination Theory* (Deci & Ryan, 2000). By earning badges and tracking progress, students were encouraged to take initiative, plan their learning strategies, and persist in completing the missions. This aligns with findings by Cicchino (2015) and Molin (2017), who highlighted that competitive and reward-based mechanisms in games strengthen students’ intrinsic motivation, leading to sustained engagement and better cognitive performance. In the context of this study, the incentive structure successfully motivated students to take responsibility for their learning and monitor their own progress, thus enhancing their self-regulatory capacity.

The musical score in the GBL media further contributed to maintaining students’ emotional engagement. The upbeat and cheerful soundtrack stimulated positive emotions, which according to Plass et al. (2020), plays a vital role in sustaining motivation and cognitive persistence in digital learning environments. Emotional design, when appropriately balanced with cognitive load, enhances learning efficiency and information retention. The results of this study therefore support the argument that affective components in educational games – such as music and sound effects – are not merely aesthetic additions but integral tools that promote sustained attention and intrinsic motivation (Bakhsh et al., 2022; Mayer, 2018).

Another strength of the developed GBL media lies in its ability to facilitate contextual and complex problem-solving. The content and skill elements in the game, which include missions, quizzes, and hint buttons, required students not only to recall factual knowledge but also to apply analytical reasoning to explain underlying scientific phenomena. The design of the challenge questions demanded students to answer “why” and “how” rather than merely “what,” aligning with higher-order cognitive processes in Bloom’s taxonomy. These findings are consistent with Hwang and Chang (2020) and Wu et al., (2012), who found that problem-solving tasks embedded in digital games enhance students’ critical thinking by encouraging them to evaluate information, test hypotheses, and make evidence-based decisions. The iterative process of trial, reflection, and feedback within the game environment thus mirrors authentic scientific inquiry, helping students develop logical reasoning and decision-making skills that are essential in science learning.

The positive impact of GBL on critical thinking observed in this study also supports previous research suggesting that game-based environments provide rich opportunities for analytical engagement. Chen and Wu (2021) found that digital role-playing games significantly improved students’ motivation and reasoning ability, while Mao et al., (2022) showed that repeated problem-solving practice in interactive games develops cognitive flexibility and reflective judgment. Similarly, Belousova et al. (2020) emphasized that digital environments enhance analytical skills by facilitating active information processing and collaborative exploration. The consistency of the present study’s results with these prior findings reinforces the pedagogical relevance of GBL as a learning approach capable of addressing cognitive and affective domains simultaneously.

In addition to improving critical thinking, the GBL media was also effective in developing self-regulated learning. Students in the experimental group demonstrated higher initiative, better time management, and increased confidence in completing learning tasks. These behaviors indicate that GBL provided a space for autonomy and self-direction. This outcome corroborates research by Wan et al., (2021), which found that interactive learning environments

empower students to plan, control, and evaluate their learning progress. The ability to play the game anytime and anywhere also contributed to students' flexibility in managing their learning schedules. Accessibility beyond the classroom environment promotes continuous engagement, which is an important component of sustained self-regulation (Mayer, 2018; Kolil et al., 2020). The evidence that students could navigate challenges independently suggests that GBL encourages the development of internal motivation and goal-oriented behaviour – both of which are vital attributes of lifelong learners.

Furthermore, the findings reveal a reciprocal relationship between self-regulated learning and critical thinking. Students who possess higher levels of self-regulation tend to demonstrate better critical thinking, as they are capable of setting learning objectives, selecting appropriate strategies, and reflecting on their progress (Zimmerman, 2002). This mutual reinforcement between metacognitive regulation and analytical reasoning has also been reported by Trekles (2012), who noted that video games encourage learners to integrate problem-solving behaviours and reflective thinking in meaningful and realistic contexts. In the case of science education, this reciprocal interaction between self-regulation and critical thinking ensures that learners not only acquire factual knowledge but also develop adaptive strategies for dealing with complex, real-world problems.

The results of this study also have theoretical and practical implications. Theoretically, the findings reaffirm that the integration of game elements grounded in cognitive and constructivist learning theories can significantly enhance students' learning experiences. The use of GBL as a pedagogical innovation supports *constructivist epistemology*, where learners actively construct knowledge through exploration, reflection, and feedback rather than passively receiving information. Practically, this research provides empirical evidence that GBL media can be implemented effectively in science learning at the junior high school level. The feasibility and practicality results indicate that both teachers and students find GBL media engaging, user-friendly, and beneficial for achieving learning goals. The product's adaptability across

different topics within science education also suggests its potential scalability for broader educational contexts.

Despite its strengths, this study recognises certain limitations. The game was developed and tested in a specific context—seventh-grade science learning in one school—so generalisation should be done cautiously. Future research should involve larger samples and diverse learning environments to verify the robustness of GBL's effectiveness. Moreover, further exploration could focus on integrating collaborative elements within GBL, such as multiplayer modes, to examine their effects on social learning and communication skills.

In summary, the discussion confirms that the developed GBL media effectively bridges the gap between students' need for engaging digital learning and the educational objective of developing critical and independent thinkers. By combining aesthetic design, narrative context, interactivity, and cognitive challenge, the GBL approach provides a multidimensional learning experience that aligns with the principles of modern pedagogy. The consistency between the findings of this research and previous studies demonstrates that game-based media, when developed systematically and grounded in sound theoretical foundations, can serve as a powerful tool for enhancing both self-regulated learning and critical thinking skills in science education.

#### **D. Conclusion**

This study developed and evaluated Game-Based Learning (GBL) media using the Game Development Life Cycle (GDLC) model to enhance self-regulated learning and critical thinking skills in science education. The results confirmed that the developed GBL media met the criteria of validity, practicality, and effectiveness. Through six development stages—initiation, pre-production, production, testing, beta, and release—the media successfully transformed conventional teacher-centred learning into a more interactive and student-centred process. Empirical tests showed that GBL significantly improved students' self-regulated learning and critical thinking skills, supporting

the view that technology-enhanced learning can stimulate autonomy and higher-order thinking.

The GBL media's success was primarily determined by its integration of cognitive, motivational, and affective components. Elements such as game mechanics, visual and narrative design, incentive systems, and music provided an engaging experience that maintained students' attention and motivation. These features allowed learners to plan, monitor, and evaluate their progress independently while facing authentic challenges that required reasoning and reflection. The findings align with previous studies (Plass et al., 2020; Sabourin et al., 2012; Hwang & Chang, 2020) that emphasise the role of interactive game design in fostering metacognitive regulation and analytical skills.

Theoretically, this research contributes to the growing body of evidence supporting the constructivist and self-determination perspectives in digital learning. GBL provides students with autonomy, competence, and meaningful engagement—three psychological conditions necessary for deep learning and sustained motivation. Practically, the developed media offers a feasible tool for teachers to integrate technology into science learning and enhance student participation. Its accessibility allows learning beyond classroom boundaries, encouraging students to take ownership of their learning and manage their study time independently. A notable finding is the reciprocal relationship between self-regulated learning and critical thinking. Students with stronger self-regulation tend to demonstrate better reasoning and decision-making skills, while those with developed critical thinking become more reflective and disciplined learners. This interconnection shows that GBL can serve as a pedagogical bridge linking cognitive and metacognitive development.

Despite these achievements, this study has several limitations. It was conducted in a single school context with a limited number of participants, so the generalization of results should be approached with caution. Future studies are recommended to apply GBL across different subjects and learning levels, with larger and more diverse samples. Research integrating collaborative or multiplayer game features could also explore how social interaction enhances

both self-regulation and critical thinking. By combining interactivity, narrative, and challenge, GBL fosters meaningful learning experiences that prepare students to become independent and analytical learners. This study provides a foundation for broader applications of game-based approaches in education, contributing to more engaging and future-oriented learning environments.

### **Acknowledgment**

The authors express their most profound appreciation to all parties who have contributed to the implementation of this research, from teachers and students to the principal and all staff of SMP Negeri 1 Sampit, as well as Yogyakarta State University, where the authors studied. Their assistance in the form of ideas, expertise, suggestions, and input was crucial in the implementation of this research and the implementation of Game-Based Learning media. Hopefully, the results of this research can provide benefits and inspire efforts to improve the quality of education in Indonesia.

### **Bibliography**

- Bakhsh, K., Hafeez, M., Shahzad, S., Naureen, B., & Farid, M. F. (2022). Effectiveness of Digital Game-Based Learning Strategy in Higher Educational Perspectives. *Journal of Education and E-Learning Research*, 9(4), 258–268. <https://doi.org/10.20448/jeelr.v9i4.4247>
- Belousova, N. A., Korchemkina, Y. V., Matuszak, A. F., Fortygina, S. N., Shulgina, T. A., Kovtun, R. F., & Permyakova, N. E. (2020). Digital Environment Components for the Formation of Students' Information and Analytical Skills. *Journal of Advanced Pharmacy Education and Research*, 10(4), 118–125. <https://japer.in/article/digital-environment-components-for-the-formation-of-students-information-and-analytical-skills>
- Capuno, J. G. C. (2023). Quizziz : A Game-based Formative Assessment Tool for Enhancing Students' Self-Regulated Learning. *International Journal of Social Learning*, 3(3), 329–340. <https://doi.org/10.47134/ijsl.v3i3.206>
- Chen, H. L., & Wu, C. T. (2023). A Digital Role-Playing Game for Learning: Effects on Critical Thinking and Motivation. *Interactive Learning Environments*, 31(5), 3018–3030. <https://doi.org/10.1080/10494820.2021.1916765>

- Cicchino, M. I. (2015). Using Game-Based Learning to Foster Critical Thinking in Student Discourse. *Interdisciplinary Journal of Problem-Based Learning*, 9(2), 4. <https://doi.org/10.7771/1541-5015.1481>
- Ekaputra, F., & Widarwati, S. (2023). Discovery Learning Based Practicum Learning in Improving Critical Thinking Skills and Student Creativity. *Tarbiyah: Jurnal Ilmiah Kependidikan*, 12(1), 47-56. <http://doi.org/10.18592/tarbiyah.9183>
- Febriyanti, F., & Imami, A. I. (2021). Analisis Self-Regulated Learning dalam Pembelajaran Matematika Pada Siswa SMP. *Jurnal Ilmiah Soulmath: Jurnal Edukasi Pendidikan Matematika*, 9(1), 1-10. <https://doi.org/10.25139/smj.v9i1.3300>
- Hake, R. R. (1998). Interactive-Engagement Versus Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses. *American Journal of Physics*, 66(1), 64-74. <https://doi.org/10.1119/1.18809>
- Hendrastomo, G., & Januarti, N. E. (2023). The Characteristics of Generation Z Students and Implications for Future Learning Methods. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, 9(2), 484-496. <https://doi.org/10.33394/jk.v9i2.7745>
- Hidayati, A. R., Fadly, W., & Ekapti, R. F. (2021). Analisis Keterampilan Berpikir Kritis Siswa pada Pembelajaran IPA Materi Bioteknologi. *Jurnal Tadris IPA Indonesia*, 1(1), 34-48. <https://doi.org/10.21154/jtii.v1i1.68>
- Hwang, G. J., & Chang, C. Y. (2020). Facilitating Decision-Making Performances in Nursing Treatments: A Contextual Digital Game-Based Flipped Learning Approach. *Interactive Learning Environments*, 31(1), 156-171. <https://doi.org/10.1080/10494820.2020.1765391>
- Jumaisyaroh, T., Napitupulu, E. E., & Hasratuddin, H. (2015). Peningkatan Kemampuan Berpikir Kritis Matematis dan Kemandirian Belajar Siswa SMP Melalui Pembelajaran Berbasis Masalah. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 5(2), 157-169. <https://doi.org/10.15294/kreano.v5i2.3325>
- Katual, D., Goede, R., & Drevin, L. (2023). Game-Based Learning to Improve Critical Thinking and Knowledge Sharing: Literature Review. *Journal of the International Society for the Systems Sciences*, 67. <https://journals.iss.org/index.php/jiss/article/view/4170>
- Kolil, V. K., Muthupalani, S., & Achuthan, K. (2020). Virtual Experimental

- Platforms in Chemistry Laboratory Education and its Impact on Experimental Self-Efficacy. *International Journal of Educational Technology in Higher Education*, 17(1), 30. <https://doi.org/10.1186/s41239-020-00204-3>
- Lampropoulos, G. (2023). Educational Benefits of Digital Game-Based Learning: K-12 Teachers' Perspectives and Attitudes Related Work. *Advances in Mobile Learning Educational Research*, 3(2), 805–817. <https://doi.org/10.25082/AMLER.2023.02.008>
- Liu, Z.-Y., Shaikh, Z. A., & Gazizova, F. (2020). Using the Concept of Game-Based Learning in Education. *International Journal of Emerging Technologies in Learning*, 15(14), 53–64. <https://doi.org/10.3991/ijet.v15i14.14675>
- Mao, W., Cui, Y., Chiu, M. M., & Lei, H. (2022). Effects of Game-Based Learning on Students' Critical Thinking: A Meta-Analysis. *Journal of Educational Computing Research*, 59(8), 1682–1708. <https://doi.org/10.1177/07356331211007098>
- Mayer, R. E. (2018). Computer Games in Education. *Annual Review of Psychology*, 70, 531–549. <https://doi.org/10.1146/annurev-psych-010418-102744>
- Meliani, F., Muhyiddin, D. S., Ruswandi, U., Arifin, B. S., & Suzana, S. (2022). Challenges of Using Technology in Islamic Religious Education Learning (Application of Flipped-Classroom in Class X PAI Subjects at SMA Plus Pagelaran Subang). *Edukasi Islami: Jurnal Pendidikan Islam*, 11(001), 41–57. <https://jurnal.staialhidayahbogor.ac.id/index.php/ei/article/view/3536>
- Molin, G. (2017). The Role of the Teacher in Game-Based Learning: A Review and Outlook. In *Serious Games and Edutainment Applications: Volume II: Vol. II* (pp. 1–702). [https://doi.org/10.1007/978-3-319-51645-5\\_28](https://doi.org/10.1007/978-3-319-51645-5_28)
- Nurhidayanti, A., Nofianti, E., Kuswanto, H., Wilujeng, I., & Suyanta, S. (2022). Analisis Kemandirian Belajar Peserta Didik SMP melalui Implementasi LKPD Discovery Learning Berbantuan Augmented Reality. *Jurnal Pendidikan Sains Indonesia*, 10(2), 312–328. <https://doi.org/10.24815/jpsi.v10i2.23719>
- Plass, J. L., Mayer, R. E., & Homer, B. D. (2020). *Handbook of Game-Based Learning*. MIT Press.
- Polit, D. F., & Beck, C. T. (2006). The Content Validity Index: Are You Sure You Know What's Being Reported? Critique and Recommendations. *Research in Nursing & Health*, 29, 489–497. <https://doi.org/10.1002/nur.20147>

- Pramana, W. D., & Dewi, N. R. (2014). Pengembangan E-Book IPA Terpadu Tema Suhu dan Pengukuran untuk Menumbuhkan Kemandirian Belajar Siswa. *Unnes Science Education Journal*, 3(3)(3), 602–608. <https://doi.org/10.15294/usej.v3i3.4267>
- Puspitasari, E. D. T., Surjono, H. D., & Minghat, A. D. (2018). Utilizing Web-Based Learning as 21st-Century Learning Media for Vocational Education. *International Journal of Engineering and Technology(UAE)*, 7(4), 157–160. <https://doi.org/10.14419/ijet.v7i4.33.23522>
- Ramadan, R., & Widayani, Y. (2013). Game Development Life Cycle Guidelines. *2013 International Conference on Advanced Computer Science and Information Systems, ICACISIS 2013*, 95–100. <https://doi.org/10.1109/ICACISIS.2013.6761558>
- Rifki, I. Y., & Lutfi, A. (2022). Development of Media Game on Acid-Base Material and Its Effect on Self-Regulated Learning. *Prisma Sains: Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, 10(1), 57-68. <https://doi.org/10.33394/j-ps.v10i1.4764>
- Sabourin, J., Shores, L. R., Mott, B. W., & Lester, J. C. (2012). Predicting Student Self-regulation Strategies in Game-Based Learning Environments. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 7315 LNCS, 141–150. [https://doi.org/10.1007/978-3-642-30950-2\\_19](https://doi.org/10.1007/978-3-642-30950-2_19)
- Safitri, R. R., Rahmania, U. G., Putri, A. F., & Jumadi, J. (2025). The Impact of Game-Based Learning on Student Competencies in Science: A Systematic Review Dampak Pembelajaran Berbasis Permainan terhadap Kompetensi Siswa dalam Sains: Tinjauan Sistematis. *Jurnal Pendidikan Dan Kebudayaan*, 10(1), 116–136. <https://doi.org/10.24832/jpnk.v10i1.5188>
- Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing Critical-Thinking Skills Through the Collaboration of Jigsaw Model with Problem-Based Learning Model. *International Journal of Instruction*, 12(1), 1077–1094. <https://doi.org/10.29333/iji.2019.12i169a>
- Saputri, A. C., Sajidan, S., & Rinanto, Y. (2018). Critical Thinking Skills Profile of Senior High School Students in Biology Learning. *Journal of Physics: Conference Series*, 1006(1), 1-5. <https://doi.org/10.1088/1742-6596/1006/1/012002>
- Setyawan, W. C., Sulthoni, S., & Ulfa, S. (2019). Pengembangan Multimedia Game Edukasi IPA. *Jurnal Kajian Teknologi Pendidikan*, 2(1), 30–36.

- <https://doi.org/10.17977/um038v2i12019p030>
- Sulisworo, D., & Sutadi, N. (2017). Science Learning Cycle Method to Enhance the Conceptual Understanding and the Learning Independence on Physics Learning. *International Journal of Evaluation and Research in Education (IJERE)*, 6(1), 64. <https://doi.org/10.11591/ijere.v6i1.6348>
- Suryanti, S., Widodo, W., & Yermiandhoko, Y. (2021). Gadget-Based Interactive Multimedia on Socio-Scientific Issues to Improve Elementary Students' Scientific Literacy. *International Journal of Interactive Mobile Technologies*, 15(1), 56–69. <https://doi.org/10.3991/IJIM.V15I01.13675>
- Syahri, U. A., Christijanti, W., & Pamelasari, S. D. (2014). Pengembangan Media Pembelajaran IPA Terpadu Berbasis Digital Games Based Learning Tema Pencemaran Lingkungan untuk Siswa SMP. *USEJ - Unnes Science Education Journal*, 3(3), 593–601. <https://journal.unnes.ac.id/sju/usej/article/view/4266>
- Trekles, A. M. (2012). Creative Writing, Problem-Based Learning, and Game-Based Learning Principles. *International Society for Technology in Education (ISTE) Conference*. <https://eric.ed.gov/?id=ED543910>
- Wan, K., King, V., & Chan, K. (2021). Examining Flow Antecedents in Game-Based Learning to Promote Self-Regulated Learning and Acceptance. *Electronic Journal of E-Learning*, 19(6), 531–547. <https://doi.org/10.34190/ejel.19.6.2117>
- Wu, W. H., Hsiao, H. C., Wu, P. L., Lin, C. H., & Huang, S. H. (2012). Investigating the Learning-Theory Foundations of Game-Based Learning: A Meta-Analysis. *Journal of Computer Assisted Learning*, 28(3), 265–279. <https://doi.org/10.1111/j.1365-2729.2011.00437.x>