

## Exploration of Emi (Electrical Monster Invaders) Through Gamification Models to Enhance Creative Thinking Skills

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| Article Info                                                                                                                                                                                                                                                                                                                                                                                     | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
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| <p><b>Article history:</b><br/> Received: March 1, 2025<br/> Accepted: May 5, 2025<br/> Published: May 11, 2025</p> <p><b>Keywords:</b><br/> Creative thinking<br/> EMI<br/> Gamification<br/> Learning motivation</p> <p>This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License</p> <p>© 2025 Berkala ilmiah Pendidikan Fisika</p> | <p>Gamification learning supports the development of learning outcomes, particularly creative thinking. To complement gamification learning, developing a suitable learning medium is necessary. Previous research has shown that gamification can improve creative thinking skills, but it is necessary to develop media that can help students develop ideas. Therefore, this study aims to analyze the validity, improvement of creative thinking, and students' responses to gamification learning assisted by EMI. The research method used is a development method with the ADDIE design. Data analysis techniques include a significant difference T-test, N-gain analysis, and Exploratory Factor Analysis (EFA) to evaluate student responses. The results indicate that EMI's feasibility falls under the category of highly valid. EMI can be used to improve creative thinking skills, with the improvement categorized as moderate. Students' responses reveal that certain factors influence the outcome, namely learning motivation and gamification. These factors positively impact the EMI learning medium. It can be concluded that EMI media can be a complementary media for gamification learning and improve students' creative thinking skills.</p> |
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### INTRODUCTION

In the 21st century, students must possess 4C skills: critical thinking, creativity, communication, and collaboration ([Khoiri et al., 2021](#); [Waluyo & Wahyuni, 2021](#)). One of the essential 4C skills is creative thinking. Education in the 21st century prioritizes creative thinking skills, demanding that students develop abilities not solely based on academic knowledge ([Abustang et al., 2023](#)). Creative thinking skills positively impact, such as generating new ideas and utilizing diverse perspectives to solve problems ([Khaerunisa et al., 2023](#); [Sueb et al., 2022](#)). Moreover, creative thinking skills are crucial in fostering students' innovation and enhancing their cognitive abilities ([Mazla et al., 2020](#); [Elidemir et al., 2020](#); [Azeem et al., 2021](#); [Thornhill et al., 2023](#); [Forte et al., 2021](#); [Istiyono et al., 2020](#)).

Students' theoretical comprehension and application of physics concepts in addressing physics-related problems requiring various skills, including creative thinking, should be the main goals of physics education ([Shah, 2019](#); [Yildiz & Guler Yildiz, 2021](#)). In the technology age, physics is crucial to education, and it is essential that students acquire the ability to think creatively about physics to succeed in the future ([Nuryadi & Widiatmaka, 2023](#); [Satriawan et al., 2020](#); [Wulandari et al., 2021](#)). Thus, physics instruction plays a big part in forming pupils' future capacity for creative thought.

However, many students still exhibit low creative thinking skills. Observational results show the following scores for creative thinking skill indicators: Fluency: 1.25; Elaboration: 2.25; Flexibility: 1.47; and Originality: 1.84. These scores are categorized as low, consistent with the study by [Prahani et al. \(2020\)](#). Research from [Madyani et al. \(2020\)](#) further supports this, indicating that Indonesian students' creative thinking skills remain low. Previous research has shown that gamification can improve creative thinking skills. However, it is necessary to develop media that can develop students' ideas because creative thinking must be able to develop ideas. Thus, a solution is urgently needed to improve students' creative thinking abilities.

Numerous efforts have been made to enhance creative thinking skills in physics education ([Huang et al., 2020](#); [Sari et al., 2021](#); [Balakrishnan, 2022](#); [Goulet-Pelletier et al., 2023](#)). Additionally, several studies suggest that challenging learning experiences can foster students' learning interests ([Filgona et al., 2020](#); [Chiu et al., 2021](#); [Rizki et al., 2023](#)). According to [Syafi'udin and Kuswandi \(2020\)](#) and [Huang et al. \(2023\)](#), gamification is one teaching approach that can enhance creative thinking and learning motivation.

Gamification is an approach that utilizes game elements to solve problems, aiming to improve performance by increasing motivation ([Marisa et al., 2020](#)). Gamification-based learning involves skills tested within games aligned with learning tasks ([Welbers et al., 2019](#)). Integrating technology into gamification-based learning can boost students' motivation to complement such learning activities ([Chu, 2019](#); [Poonsawad et al., 2022](#)). That necessitates developing learning media to enhance creative thinking skills through gamification models. Based on this context, the purpose of this research is to analyze the feasibility of the media; this requires the development of learning media to improve creative thinking skills through gamification models. Based on this context, the purpose of this study is to analyze the development of the media, so that the objectives of this study include analyzing the validity of EMI media in improving creative thinking skills, analyzing the increase in creative thinking skills after using EMI media, and analyzing student responses after using EMI media.

## METHODS

The research method used in this study is the R&D (research and development) method. R&D is a research model aimed at creating a specific product and testing its feasibility ([Sugiyono, 2020](#)). The development model applied in this research is the ADDIE development model. The research design is structured as illustrated in Figure 1 ([Anglada, 2007](#)).



Figure 1 Research design

In this research design, the researchers limit the scope of the study to the stages of analyze and development. The data-collecting method was implemented in phases using the ADDIE design. The researchers examined the pupils' requirements and circumstances in the first phase. The researchers created educational materials based on the students' requirements and circumstances in the second phase. During this phase, the researchers

additionally created the media by offering a validation sheet. The researchers used and assessed the press in the third stage—the media implementation aimed to enhance the students' capacity for original thought. Table 1 displays the markers of innovative thinking that were employed ([Guilford, 1967](#)).

Table 1 Indicators of creative thinking

| Indicators of creative thinking ability | Creative thinking behavior                                                                                           |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Fluency                                 | a) Being able to make some meaningful answers<br>b) Having smooth flow of thoughts                                   |
| Elaboration                             | a) Expanding an idea<br>b) Having the ability to detail certain details<br>c) Developing an idea                     |
| Flexibility                             | a) Being able to make answers from different perspectives<br>b) Being able to convey ideas from different directions |
| Originality                             | The many variations in giving answers that are different from others                                                 |

This development research conducted two validation stages: expert and empirical. According to [Situmorang & Purba \(2019\)](#), validity testing aims to determine whether the developed learning media is valid or not. Expert validators and one school teacher validated the developed media. The criteria for determining the validity of the media are presented in Table 2 ([Arikunto, 2016](#)).

Table 2 Validation percentage criteria

| Percentage (%) | Validity Criteria |
|----------------|-------------------|
| 0-20           | Very Poor         |
| 21-40          | Poor              |
| 41-60          | Fair              |
| 61-80          | Valid             |
| 81-100         | Highly Valid      |

After completing the validation stage, the researchers conducted a limited trial to analyze the improvement in students' creative thinking skills. To determine whether there was a significant difference, a simple paired T-test was used along with prerequisite tests, including normality and homogeneity tests ([Sugiyono, 2014](#)). If the prerequisite tests were not met, the Wilcoxon test was used. The n-gain criteria were applied to evaluate the requirements for improving creative thinking skills. The n-gain criteria are presented in Table 3 ([Adilla & Jatmiko, 2021](#); [Wardani & Jatmiko, 2021](#)).

Table 3 N-gain criteria

| Value                                | Criteria |
|--------------------------------------|----------|
| $\langle g \rangle \geq 0.70$        | High     |
| $0.70 > \langle g \rangle \geq 0.30$ | Medium   |
| $\langle g \rangle < 0.30$           | Low      |

The evaluation results were analyzed using Exploratory Factor Analysis (EFA). EFA is used to explore the factor structure of quantitative data and identify the main dimensions underlying the factors resulting from the use of EMI media ([Wang et al., 2024](#)).

## RESULTS AND DISCUSSION

### Analysis Stage

Before conducting further analysis, it is necessary to understand the existing conditions. This is a preliminary study that aims to identify the students' needs and initial skills. The results of the students' initial creative thinking skills are presented in Figure 2.

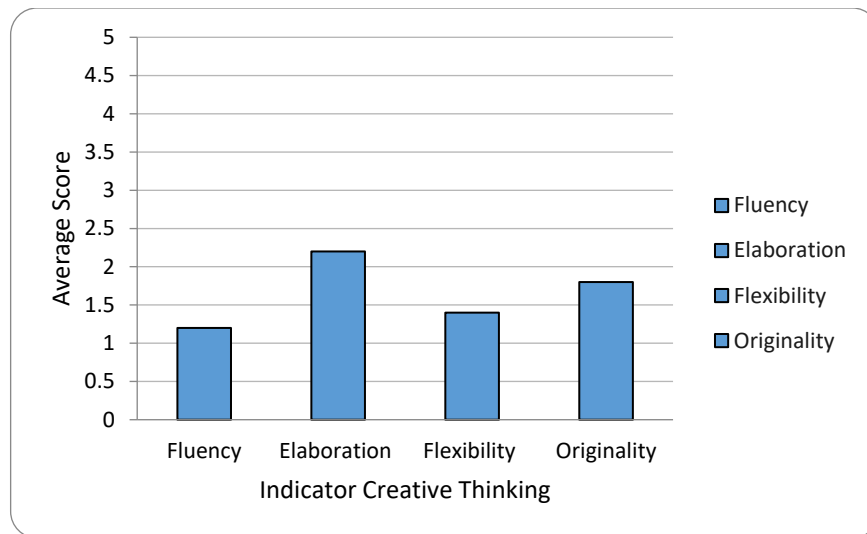


Figure 2 Results of initial creative thinking skills

Based on Figure 2, the average score for each indicator of students' creative thinking skills did not reach a value of 3. [Prahani et al. \(2020\)](#) say this result falls under the low category. That is due to many students perceiving physics as difficult and tedious. Therefore, a survey was conducted on strategies to make students enjoy physics learning. The survey results showed that 26 students preferred learning through games. Consequently, the researchers aimed to develop game-based media and implement physics learning using games.

### Design Stage

At this stage, the researchers designed the media to be developed based on electromagnetic induction. Figure 3 illustrates the media design stage.



Figure 3 EMI media design

Based on Figure 3, the design is created to enhance students' creative thinking skills in physics concepts, specifically electromagnetic induction. The game concept involves students building a generator capable of lighting up a city. The challenge in this game is that students will be provided with the tools needed to construct the generator. They must select the appropriate tools to build the generator successfully.

Based on Figure 4, the physics concept applied in this game is electromagnetic induction (Faraday's Law), which states that a change in magnetic flux in a coil of wire will generate an electric voltage. Based on the illustration (Figure 4), six main components are required to build a generator: a U-shaped magnet, a 5000-turn wire coil, a drill, nails, a light bulb, and tape.



Figure 4 Game Challenge Design in EMI

### Development Stage

At this stage, the researchers conducted a validity test involving a teacher and learning media experts. The validity aspects assessed included attractiveness, content relevance, media quality, and language. The results of the validity test are presented in Table 4.

Table 4 Validation results

| Validity Test     |             |             |             |         |              |
|-------------------|-------------|-------------|-------------|---------|--------------|
| Aspects           | Validator 1 | Validator 2 | Validator 3 | Average | Criteria     |
| Attractiveness    | 88%         | 94%         | 100%        | 94%     | Highly Valid |
| Content Relevance | 92%         | 100%        | 83%         | 92%     | Highly Valid |
| Media Quality     | 100%        | 92%         | 100%        | 97%     | Highly Valid |
| Language          | 100%        | 100%        | 100%        | 100%    | Highly Valid |

The results indicate that all aspects received the criteria of "Highly Valid." This demonstrates that the developed media is suitable for limited trials with students. These limited trials are intended to evaluate the developed media, allowing it to be further refined and generalized.

### Implementation Stage

At this stage, the researchers conducted a trial of EMI media with a gamification model. The results obtained are as in Table 5.

Table 5. EMI Media Implementation Results

|      | N  | Average Score | Std. Deviation | N-gain | Criteria | Sig. 2 Tailed |
|------|----|---------------|----------------|--------|----------|---------------|
| Pre  | 36 | 34.16         | 11.55          | 0.53   | Medium   | 0.00          |
| Post |    | 68.75         | 10.44          |        |          |               |

The results obtained show a significant difference with moderate criteria. This shows that EMI media with gamification learning can improve students' creative thinking skills. According to research by [Lee \(2023\)](#), Gamification effectively improves creative thinking skills. Research conducted by [Damarsha et al. \(2025\)](#) needs to develop media that can improve creative thinking skills. At this stage, the researchers were still in the initial stage, resulting in a medium criterion N-gain value, which means it needs to be improved for the next stage.

### Evaluation Stage

At this point, the researchers assessed the outcomes of the media produced. The first assessment is the outcome of the validator's assessment. Table 6 shows the outcomes of the validator's enhancement recommendations.

Table 6 Validator suggestions

| Validator | Comment                                                |
|-----------|--------------------------------------------------------|
|           | Animation quality is not engaging enough for students. |
|           | Provide instructions for using the media.              |
|           | Features used are insufficient                         |

Among the outcomes derived from the validators' recommendations is providing more captivating animations for students. The validity test results on the beauty component, which had the lowest percentage of 88% (Table 4), are consistent. Students tended to become uninterested since the animations on display lacked visual effects. Therefore, more visually appealing effects must be included to maintain student engagement. That is in line with [Sastradika's \(2021\)](#) research, which found that motivating animation elements can increase students' motivation. Furthermore, captivating and engaging visual effects can simplify complex ideas, making learning them more pleasurable and easy.

Giving directions on how to use the gamification learning materials was the second recommendation made by the validators. This is consistent with the content relevance aspect's validity test findings, which showed the lowest percentage, 83% (Table 4). Some students were unsure how to use the media because there were no instructions. Usage instructions must be added to boost students' excitement, attention, and involvement ([Agyeiwaah et al., 2022](#); [Harefa, 2023](#)). That is corroborated by research by Sumiharsono & Hasanah (2017), who found that learning media serve at least three main functions: presenting knowledge, inspiring interest, and giving instructions.

The validators' final recommendation was that the gamification learning materials' features were inadequate. This is consistent with the validity test findings on the media quality aspects, which showed the lowest proportion, 92% (Table 4). Students become inert and less engaged in the learning process due to the learning media's lack of features. Students also lacked the motivation to learn. Therefore, its features must be improved to make the learning media more appropriate. Improving the learning media's characteristics can boost student engagement, learning motivation, and subject comprehension.

### Evaluation stage on the Student's

The data analysis procedure from the instrument, a questionnaire on gamification learning media (EMI), is offered to address students' responses. With a significant Bartlett's test result ( $\chi^2 = 791.984$ ,  $df = 120$ ,  $p < 0.001$ ) and a Kaiser–Meyer–Olkin (KMO) value of 0.772, the table suggests that the data is appropriate for factor analysis (Suprpto, 2019). All three Principal Component Analysis (PCA)-proposed factors have eigenvalues more significant than one (Figure 5 and Table 8).

Table 7 KMO test

|                                                        |                    |         |
|--------------------------------------------------------|--------------------|---------|
| Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy. |                    | 0.772   |
| Bartlett's Test of Sphericity                          | Approx. Chi-Square | 791.984 |
|                                                        | Df                 | 120     |
|                                                        | Sig.               | 0.000   |

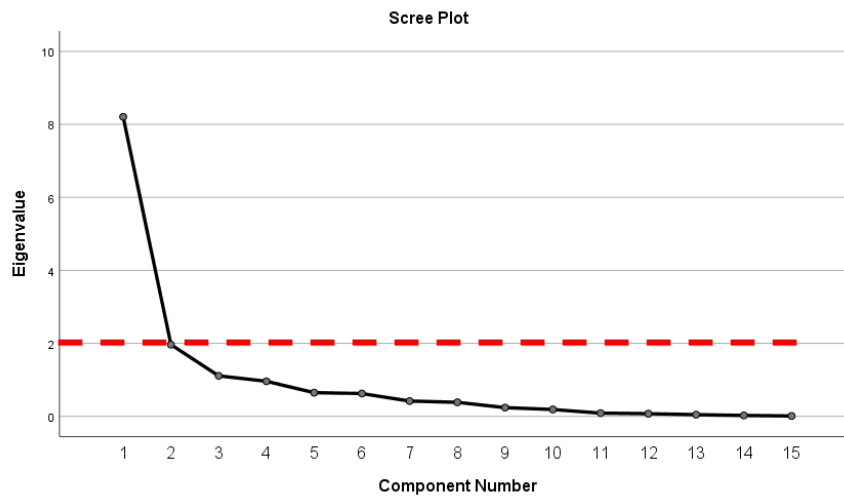


Figure 5 Eigenvalue Diagram

Table 8 Eigenvalue Factors

| Component (Factors) | Initial Eigenvalue |               |              |
|---------------------|--------------------|---------------|--------------|
|                     | Total              | % of Variance | Cumulative % |
| 1                   | 12.463             | 77.897        | 77.897       |
| 2                   | 1.058              | 6.613         | 84.510       |

Both factors contribute 84.51% of the total variance. These factors represent students' responses to the gamification learning media Electrical Monster Invaders (EMI) and are intended to measure each factor loading between 0.507 and 0.907. Factor loadings below 0.400 were excluded from the analysis (Suprpto & Ku, 2016; Suprpto, 2019). The Cronbach's alpha values for the two factors are 0.972 and 0.960, respectively, with an overall Cronbach's alpha value of 0.981, as shown in Table 9.

Table 9 Loading Factor

| Item | Loading Factors          |                         |
|------|--------------------------|-------------------------|
|      | (MB)<br>$\alpha = 0.972$ | (G)<br>$\alpha = 0.960$ |
| BK2  | 0.920                    |                         |
| MB3  | 0.824                    |                         |
| MP3  | 0.813                    |                         |
| MB4  | 0.787                    |                         |
| MB1  | 0.771                    |                         |
| G4   | 0.744                    |                         |
| MP1  | 0.718                    |                         |
| MB2  | 0.698                    |                         |
| BK4  | 0.679                    |                         |
| MP2  | 0.403                    |                         |
| G1   |                          | 0.873                   |
| MP4  |                          | 0.856                   |
| G3   |                          | 0.824                   |
| G2   |                          | 0.823                   |
| BK3  |                          | 0.665                   |
| BK1  |                          | 0.620                   |

Total Variance Explained = **84.51%** and Overall Cronbach Alpha = **0.981**

Explanation:

MB : Learning Motivation  
 G : Gamification  
 BK : Creative Thinking  
 MP : Learning Media

The results of the EFA analysis indicate that the 16 questionnaire items can be grouped into two factors: **MB** (Learning Motivation) and **G** (Gamification). To further analyze, the indicators for each factor were averaged, resulting in a diagram as illustrated in Figure 6.

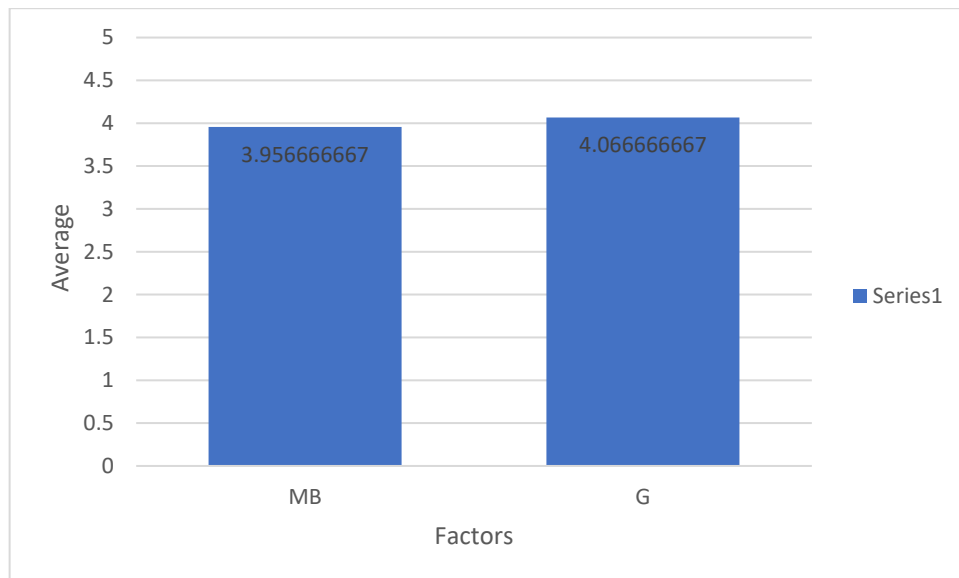


Figure 6 Diagram of each factor

The diagram indicates that the Gamification (G) factor has the highest average. This demonstrates that the developed media successfully engages students' interest in learning physics through the gamification method. However, the Learning Motivation (MB) factor shows the lowest average. This is attributed to students being moderately motivated by the developed media.

Feedback from students suggests that the visualization in the media is not sufficiently engaging. Future research is therefore encouraged to develop gamification-based learning media with significantly enhanced visualizations to improve student motivation and engagement.

### CONCLUSION

The findings of this study conclude that the EMI media using a gamification model is categorized as highly valid. Several suggestions from validators regarding the EMI media are for improvement in future research. One of the key improvements needed is enhancing the quality of the animation, aimed at increasing students' learning motivation. The trial results of EMI media showed a moderate improvement in students' creative thinking skills. The results of the student responses analyzed using EFA indicate that the EMI media influences both gamification and learning motivation factors. The findings reveal that the gamification factor has a high impact, as students are highly engaged with the game challenges. Meanwhile, the learning motivation factor is moderately high, attributed to the less appealing visualization presented to students. The results obtained indicate that EMI media can be a complement to gamification learning and can improve creative thinking skills. This research hopes to impact increasing creative thinking through gamification learning. For future research, it can be done by developing media that has varied animations so that students' interest in learning increases. For future research, it can be done by developing media that has varied animations so that students' interest in learning increases.

### CONFLICTS OF INTEREST

The author declares that there is no conflict of interest.

# AUTHOR CONTRIBUTIONS STATEMENT

Game concept: MGN, IMA, ABD; Media editor: MSI; Methodology: MS, IMA, VFS; Article draft: MGN, IMA, MSI, VFS, ABD, MS, IAR

# REFERENCES

- Abustang, P. B., Marini, A., & Wibowo, F. C. (2024). Creative thinking skill in the elementary education bibliometric study literature. *AIP Conference Proceedings*, 3116(1). <https://doi.org/10.1063/5.0210276>.
- Adilla, I. N., & Jatmiko, B. (2021). Keefektifan pembelajaran daring fisika sma berbasis probing prompting untuk meningkatkan keterampilan berpikir kritis peserta didik. *PENDIPA Journal of Science Education*, 5(3), 426–435. <https://doi.org/10.33369/pendipa.5.3.426-435>.
- Agyeiwaah, E., Baiden, F. B., Gamor, E., & Hsu, F. C. (2022). Determining the attributes that influence students' online learning satisfaction during COVID-19 pandemic. *Journal of Hospitality, Leisure, Sport & Tourism Education*, 30, 100364.
- Anglada, D. (2007). An introduction to instructional design: Utilizing a basic design model. 208–216.
- Arikunto, S. (2016). *Prosedur penelitian suatu pendekatan praktik*. Jakarta: PT. Rineka Cipta.
- Azeem, M., Ahmed, M., Haider, S., & Sajjad, M. (2021). Expanding competitive advantage through organizational culture, knowledge sharing and organizational innovation. *Technology in Society*, 66. <https://doi.org/10.1016/j.techsoc.2021.101635>.
- Balakrishnan, B. (2022). Exploring the impact of design thinking tool among design undergraduates: A study on creative skills and motivation to think creatively. *International Journal of Technology and Design Education*, 32(3), 1799–1812. <https://doi.org/10.1007/s10798-021-09652-y>.
- Chu, H. E., Martin, S. N., dan Park, J. (2019). Theoretical framework for developing an intercultural steam program for australian and korean students to enhance science teaching and learning. *International Journal of Science and Mathematics Education I*. 17(7), 1251 – 1266. <https://doi.org/10.1007/s10763-018-9922-y>.
- Chiu, T. K., Lin, T. J., & Lonka, K. (2021). Motivating online learning: The challenges of COVID-19 and beyond. *The asia-pacific education researcher*, 30(3), 187-190.
- Damarsha, A. B., Saputra, O., Suprpto, N., Hariyono, E., & Nisa', K. (2025). Integration of virtual simulation of traditional kekehan games on the material of moment of inertia and angular momentum. *JPPS (Jurnal Penelitian Pendidikan Sains)*, 14(1), 51–63. <https://doi.org/10.26740/jpps.v14n1.p51-63>.
- Elidemir, S. N., Ozturen, A., & Bayighomog, S. W. (2020). Innovative behaviors, employee creativity, and sustainable competitive advantage: A moderated mediation. *Sustainability (Switzerland)*, 12(8). <https://doi.org/10.3390/SU12083295>.
- Filgona, J., Sakiyo, J., Gwany, D. M., & Okoronka, A. U. (2020). Motivation in learning. *Asian Journal of Education and social studies*, 10(4), 16-37.
- Forte-Celaya, J., Ibarra, L., & Glasserman-Morales, L. D. (2021). Analysis of creative thinking skills development under active learning strategies. *Education Sciences*, 11(10). <https://doi.org/10.3390/EDUCSCI11100621>.
- Guilford, J. P. (1967). *The nature of human intelligence*. New York, NY: McGraw-Hill Book Company.
- Goulet-Pelletier, J. C., Gaudreau, P., & Cousineau, D. (2023). Do students motivated to learn have better creative abilities?. *Learning and Individual Differences*, 106, 102327. <https://doi.org/10.1016/j.lindif.2023.102327>.
- Harefa, D. (2023). The relationship between students'interest in learning and mathematics learning outcomes. *AFORE: Jurnal Pendidikan Matematika*, 2(2), 1-11.

- Huang, N. T., Chang, Y. S., & Chou, C. H. (2020). Effects of creative thinking, psychomotor skills, and creative self-efficacy on engineering design creativity. *Thinking skills and creativity*, 37, 100695.
- Huang, W., Li, X., & Shang, J. (2023). Gamified project-based learning: A systematic review of the research landscape. *Sustainability*, 15(2), 940.
- Istiyono, E., Widiastuti, Supahar, & Hamdi, S. . (2020). Measuring creative thinking skills of senior high school male and female students in physics (CTSP) using the IRT-based physTCreTS. *Journal of Turkish Science Education*, 17(4), 578-590. <https://doi.org/10.36681/tused.2020.46>.
- Khaerunisa, N. A., Serevina, V., & Wibowo, F. C. (2024). The effect of STEM-PjBL on students' creative thinking skills and self-efficacy. *AIP Conference Proceedings*, 3116(1). <https://doi.org/10.1063/5.0211075>.
- Khoiri, A., Komariah, N., Utami, R. T., Paramarta, V., & Sunarsi, D. (2021). 4Cs analysis of 21st century skills-based school areas. *Journal of Physics: Conference Series*, 1764(1), 012142. IOP Publishing.
- Lee, K. W. (2023). Effectiveness of gamification and selection of appropriate teaching methods of creativity: Students' perspectives. *Heliyon*, 9(10).
- Madyani, I., Yamtinah, S., Utomo, S. B., Saputro, S., & Mahardiani, L. (2020). Profile of students' creative thinking skills in science learning. In *3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019)* (pp. 957-964). Atlantis Press.
- Marisa, F., Akhriza, T. M., Maukar, A. L., Wardhani, A. R., Iriananda, S. W., & Andarwati, M. (2020). Gamifikasi (gamification) konsep dan penerapan. *JOINTECS (Journal of Information Technology and Computer Science)*, 5(3), 219. <https://doi.org/10.31328/jointecs.v5i3.1490>.
- Mazla, M. I. S. B., Jabor, M. K. B., Tufail, K., Yakim, A. F. N., & Zainal, H. (2020). The roles of creativity and innovation in entrepreneurship. In *International Conference on Student and Disable Student Development 2019 (ICoSD 2019)* (pp. 213-217). Atlantis Press.
- Nuryadi, M. H., & Widiatmaka, P. (2023). Strengthening civic literacy among students through digital literacy in society 5.0. *Journal of Education and Learning (EduLearn)*, 17(2), 215-220.
- Poonsawad, A., Srisomphan, J., & Sanrach, C. (2022). Synthesis of problem-based interactive digital storytelling learning model under gamification environment promotes students' problem-solving skills. *International Journal of Emerging Technologies in Learning*, 17(5), 103–119. <https://doi.org/10.3991/ijet.v17i05.28181>.
- Prahani, B. K., Ramadani, A. H., Kusumawati, D. H., Suprpto, N., Madlazim, M., Jatmiko, B., & Deta, U. A. (2020). ORNE learning model to improve problem-solving skills of physics bachelor candidates: An alternative learning in the COVID-19 pandemic. *Jurnal Penelitian Fisika dan Aplikasinya (JPFA)*, 10(1), 71-80.
- Rizki, I. A., Saphira, H. V., Alfarizy, Y., Saputri, A. D., Ramadani, R., & Suprpto, N. (2023). Adventuring physics: Integration of adventure game and augmented reality based on android in physics learning. *International Journal of Interactive Mobile Technologies*, 17(1).
- Sari, F. P., Nikmah, S., Kuswanto, H., & Wardani, R. (2020). Development of physics comic based on local wisdom: Hopscotch (engklek) game android-assisted to improve mathematical representation ability and creative thinking of high school students. *Revista Mexicana de Fisica E*, 17(2), 255-262.
- Sastradika, D., Iskandar, I., Syefrinando, B., & Shulman, F. (2021). Development of animation-based learning media to increase student's motivation in learning physics. *Journal of Physics: Conference Series*, 1869(1), 012180. IOP Publishing.

- Satriawan, M., Rosmiati, R., Widia, W., Sarnita, F., Suswati, L., Subhan, M., & Fatimah, F. (2020). Physics learning based contextual problems to enhance students' creative thinking skills in fluid topic. *Journal of Physics: Conference Series*, 1521(2), 022036. IOP Publishing.
- Shah, R. K. (2019). Effective social constructivist approach to learning for social studies classroom. *Journal of Pedagogical Research*, 3(2), 38–51.
- Situmorang, E., & Purba, D. (2019). Perancangan aplikasi pengujian validitas dan reliabilitas instrumen penelitian. *Kakifikom (Kumpulan Artikel Karya Ilmiah Fakultas Ilmu Komputer*, 1(2), 54–58.
- Sueb, S., Muhdhar, M. H. I. al, Wardhani, Y. S., Abdillah, R. R., Wulandari, I. A. I., Astuti, L., Suhadi, S., & Achmad, R. (2024). The effectiveness of adiwiyata electronic module based on reading mind mapping CIRC to improve students' creative thinking skills, adaptability skills, and environmental literacy. *AIP Conference Proceedings*, 3106(1). <https://doi.org/10.1063/5.0215342>.
- Sugiyono, S. (2020). Metode penelitian kuantitatif kualitatif dan R&D. Bandung: Alfabeta.
- Sugiyono, S. (2014). Metode penelitian pendidikan pendekatan kuantitatif, kualitatif, dan R&D. Bandung: Alfabeta.
- Suprpto, N. (2019). Demographic sources as a local wisdom: Potency of Indonesian physics education researchers in conducting survey research. *Journal of Physics: Conference Series*, 1171(1), 012003. IOP Publishing.
- Suprpto, N., & Ku, C. H. (2016). Investigating university students' preferences to science communication skills: A case of prospective science teacher in indonesia. *International Education Studies*, 9(8), 19-27.
- Syafi'udin, H., & Kuswandi, D. (2020, February). Problem-based learning with the gamification approach in ecopedagogy for children aged 4–7 years: A case study of kampung kramat malang, indonesia. In *International Conference on Social Studies and Environmental Issues (ICOSSEI 2019)* (pp. 84-88). Atlantis Press.
- Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., el Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, critical thinking, communication, and collaboration: assessment, certification, and promotion of 21st century skills for the future of work and education. *Journal of Intelligence*, 11(3). MDPI. <https://doi.org/10.3390/jintelligence11030054>.
- Waluyo, R., & Wahyuni, S. (2021). Development of STEM-based physics teaching materials integrated 21st century skills (4C) and characters. *Formatif: Jurnal Ilmiah Pendidikan Mipa*, 11(1), 83-102.
- Wang, X., Yuan, L., Li, S., Yu, H., Tuo, P., Du, Y., & Zhang, B. (2024). Developing and validating an interdisciplinary teaching readiness scale (itrs) for pre-service teachers in china. *PLoS ONE*, 19(12). <https://doi.org/10.1371/journal.pone.0315723>.
- Wardani, C., & Jatmiko, B. (2021). The effectiveness of tpack-based learning physics with the pbl model to improve students' critical thinking skills. *International Journal of Active Learning*, 6(1), 17-26.
- Welbers, K., Konijn, E. A., Burgers, C., de Vaate, A. B., Eden, A., & Brugman, B. C. (2019). Gamification as a tool for engaging student learning: A field experiment with a gamified app. *E-Learning and Digital Media*, 16(2), 92–109. <https://doi.org/10.1177/2042753018818342>.
- Wulandari, D., Hariyono, E., Suprpto, N., Hidaayatullaah, H. N., & Prahani, B. K. (2021). Profile of students' creative thinking skills on global warming material: Gender perspective in physics learning. *Journal of Physics: Conference Series*, 2110(1), 012028. IOP Publishing.

Yildiz, C., & Guler Yildiz, T. (2021). Exploring the relationship between creative thinking and scientific process skills of preschool children. *Thinking Skills and Creativity*, 100795. <https://doi.org/10.1016/j.tsc.2021.100795>.

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