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Development of Gamified Interactive Learning Media for Thermal Concepts to Foster Students' Conceptual Understanding and Creativity

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Abstract

Science materials at the junior high school level often pose challenges for students, particularly in understanding abstract concepts and differentiating between topics such as temperature, heat, and expansion. These difficulties contribute to low levels of conceptual understanding and limited student creativity. This study aims to develop and evaluate gamification-based interactive science media integrated with the discovery learning model to enhance students' conceptual understanding and creativity. The study employed a Research and Development (R&D) approach using the ADDIE model and utilized a quasi-experimental design. The participants included 64 seventh-grade students from SMP Negeri 41 Semarang, divided into experimental (class VIIB) and control (class VIIE) groups. The validity assessment yielded high scores for both media (0.90) and material content (0.94). Practicality evaluations demonstrated strong approval from both students (82.97%) and teachers (88.33%). Effectiveness analysis revealed a significant increase in conceptual understanding (N-gain: 0.71, high category) and creativity (N-gain: 0.62, medium category) in the experimental group, while the control group showed lower gains (N-gain: 0.44 and 0.29, respectively). These results indicate that gamified interactive media combined with the discovery learning model is valid, practical, and effective in enhancing students' conceptual understanding and creativity. This study highlights the potential of integrating gamification into interactive learning environments to foster deeper engagement and improved learning outcomes in science education at the junior high school level. The findings suggest that such innovative approaches can be widely adopted to support active learning and creativity development among students.

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INTRODUCTION

According to Bundu (as cited in Susanti et al., 2021), students' low understanding of science concepts is attributed to the traditional teaching approach, which relies heavily on teacher-centered lectures and fails to involve students in the learning process actively. Additionally, Pusparani and Selamet (2021) argue that the lack of adequate science learning media is a significant factor contributing to students' difficulties in learning. Media are essential tools for facilitating students' comprehension of abstract science concepts. With the rapid advancement of technology in the digital era, learning media have been designed using various applications that enhance the creation and delivery of educational content (Suryadi, 2020).

Science lessons are closely connected to everyday life and can be enriched through experiments, observations, and theoretical exploration. Ismayani (2016) and Ekantini (2020) assert that science learning becomes more meaningful when students engage in processes of discovery, experimentation, or direct experience, which are essential for understanding key concepts across various scientific disciplines. The ability to grasp these concepts is a critical indicator of success in science education. However, one of the challenges faced in science learning is low conceptual understanding, which negatively affects students' performance in their PTS and PAS assessments (Ibrahim & Dewi, 2019).

Creativity is one of the 21st century skills that students must have (Magfiroh et al., 2016). Research by Dewi et. al (2019) states that creativity skills in Indonesia are still relatively low, reinforced by the results of The Global Creativity in 2015, Indonesia was in 115th position out of 139 countries (Qomariyah & Subekti, 2021). According to Muderawan et al. (2019) there are two factors that cause students' difficulties and reluctance in learning science influenced by internal factors and external factors. Internal factors that influence students' difficulties in learning are interest, talent, motivation, considering science as a difficult subject and intelligence in the students themselves (Amaliyah et al., 2021). Furthermore, external factors that influence are the methods applied by teachers, school facilities, facilities and infrastructure, the use of monotonous learning media (Pusparani & Selamet, 2021).

Interactive media refers to tools that engage students by allowing them to interact with the content and receive feedback from the material presented (Haleem et al., 2022; Swasti et al., 2022). Previous research has explored the use of interactive media, including studies by Cahaya et al. (2022), Nendhita and Kelana (2023), and Namri et al. (2023). The Discovery Learning model is one of the instructional strategies that can enhance students' understanding of concepts. In line with this, Siahaan and Sihotang (2023) found that the Discovery Learning model positively impacted junior high school student's understanding of science concepts. Similarly, Swasti et al. (2022) demonstrated that the Discovery Learning model facilitated student comprehension of scientific concepts and, as noted by Safriani et al. (2015), also contributed to enhancing student creativity. Furthermore, research by Husnawati and Carina (2023) indicates that gamification can foster enjoyment and increase interaction, making the learning process both effective and enjoyable. Studies incorporating gamification, such as those by Mertayasa et al. (2022) and Hakeu et al. (2023), have shown that it can improve students' conceptual mastery and critical thinking skills, as well as boost their interest in learning (Asrul et al., 2023). One of the challenges teachers and students face is the lack of adequate learning media to support the learning process, which contributes to low conceptual understanding and creativity. Additionally, creativity is a key competency for 21st-century skills. According to Dewi et al. (2019), creativity skills in Indonesia are still relatively low, a finding supported by The Global Creativity Index, which ranked Indonesia 115th out of 139 countries in 2015 (Qomariyah & Subekti, 2021).

Previous studies have not extensively explored combining the Discovery Learning model with gamification and interactive media as student learning resources. The novelty of this research lies in the development of interactive science learning media that integrates game elements with the Discovery Learning model, aiming to create an interactive, active, and enjoyable learning experience that encourages students to discover concepts independently. Therefore, the researcher

aims to develop interactive learning media based on gamification in conjunction with the Discovery Learning model. This study aims to evaluate interactive science media's validity, practicality, and effectiveness based on gamification, focusing on temperature, heat, and expansion materials, in enhancing students' conceptual understanding and creativity. The benefits of this study include providing a resource that aids in improving the conceptual understanding and creativity of junior high school students, particularly in grade VII, concerning temperature, heat, and expansion concepts. While previous studies have primarily focused on developing gamification-based interactive learning media without integrating specific learning approaches or models, the findings of this study can serve as a reference for further development of gamification-based educational resources.

METHODS

This study employed a Research and Development (R&D) approach using the ADDIE model—Analysis, Design, Development, Implementation, and Evaluation—as Sugiyono (2016) outlined to develop gamification-based interactive science learning media integrated with the discovery learning model.

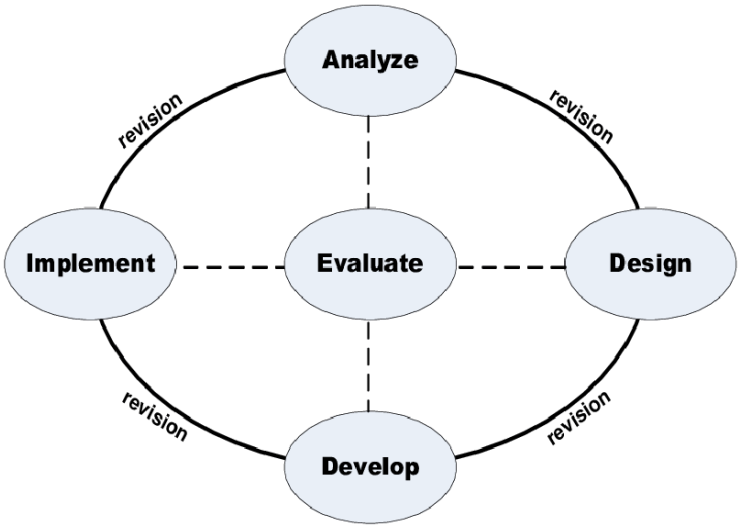

Figure 1. Model ADDIE

In the analysis stage, interviews with science teachers were conducted to identify problems related to current learning media. The design stage involved creating a prototype that integrated text, images, games, and videos. During development, the media was created using Canva and validated by media and content experts, followed by small-scale testing with ten students to identify and revise any deficiencies. In the implementation stage, the media was applied in a quasi-experimental design (Pretest-Posttest Control Group Design) involving two classes: VIIB (experimental) and VIIE (control) at SMP Negeri 41 Semarang. Both groups completed a pretest, underwent their respective treatments (interactive vs. conventional learning), and then completed a posttest to measure conceptual understanding through multiple-choice tests and creativity through mind-mapping tasks. Finally, in the evaluation stage, student feedback was collected via questionnaires, and data analysis included pretest-posttest item analysis, prerequisite tests (normality and homogeneity), and effectiveness analysis using T-test and N-Gain calculations.

RESULTS AND DISCUSSION

Validation Test of Interactive Media Based on Gamification With The Discovery Learning Model

The feasibility of interactive science media based on gamification with the discovery learning model developed will be analyzed using the Aiken V formula to test the validation results by media experts and material experts. The validity of

interactive science media based on gamification with the discovery learning model is known by calculating the validation results three by science teachers who are media and material experts and two by lecturers who are media and material experts to determine the feasibility of the media as a source of learning and the accuracy of the product developed. Valid instruments have high validity. Less valid instruments will have low validity (Sürücü & Maslakci, 2020; Arikunto, 2016). The following is the Aiken's V formula used to state the validity of the media:

$$V = \frac{\sum s}{[n(c-1)]} \text{ where } s = r - Lo$$

Information:
Lo = lowest validity assessment number
C = highest validity assessment number
r = number given by experts
n = number of expert assessors

The following are the results of media and material validation by five validators: Table 1 is the result of media validation, and Table 2 is the result of material validation declared valid with a calculated V value of 0.87 or more.

Table 1. Media validation results

No	Rated aspect	Average		Information
		V_{count}	V_{table}	
1	Usability	0.87	0.87	Valid
2	Convenience	1.00	0.87	Valid
3	Appearance	0.91	0.87	Valid
4	Attractiveness	0.89	0.87	Valid
5	Audio/sound	0.87	0.87	Valid
Average		0.90	0.87	Valid

Table 2. Material validation results

No	Rated aspect	Average		Information
		V_{count}	V_{table}	
1	Curriculum	0.96	0.87	Valid
2	Methods	1.00	0.87	Valid
3	Evaluation	0.91	0.87	Valid
4	Language	0.93	0.87	Valid
5	Benefits	0.93	0.87	Valid
Average		0.94	0.87	Valid

The study employed five expert validators using a four-category Likert scale ranging from 1 to 4. According to the standard established by Aiken, as cited in Merino-Soto (2023), Nurjanah et al. (2023) and Azwar (2016), an instrument or media is considered valid if the coefficient value exceeds 0.87. Based on the validation results, the interactive science media developed—based on gamification and integrated with the discovery learning model—was deemed valid and appropriate for classroom implementation. This interactive media was specifically designed to teach the topics of temperature, heat, and expansion in junior high school science curricula.

The Effectiveness of Interactive Media Based on Gamification of The Discovery Learning Model in Improving Conceptual Understanding

Based on the pretest and posttest results on students' conceptual understanding, a significant improvement was observed in the experimental class compared to the control class. The experimental class, which utilized gamification-based interactive science media integrated with the discovery learning model, achieved an N-Gain score of 0.70, categorized as high. In contrast, the control class obtained an N-Gain score of 0.51, categorized as moderate. These findings indicate that the implementation of gamified interactive media can effectively enhance students' conceptual understanding. This aligns with the study by Azizah

et al. (2023), which found that the use of Wordwall media supports conceptual understanding, and with Gusman et al. (2021), who reported a positive educational impact of technology-integrated learning tools. A solid and in-depth conceptual understanding facilitates students' ability to interpret scientific phenomena more effectively. Furthermore, the discovery learning model encourages students to engage in simple experiments, promoting active learning. Supporting this, Mutia and Adri (2025) found that science learning through experimental methods and collaborative group activities significantly improves students' comprehension and academic performance. Additionally, an increase in student achievement in the cognitive domain was reported by Sofiyati et al. (2020) and Peng & Kievit (2020). A detailed analysis of the student's conceptual understanding based on pretest and posttest results is presented in Table 3.

Table 3. Pretest and posttest analysis of students' conceptual understanding

Class	Pretest Average	Posttest Average	N-Gain	Criteria
Experiment	46	84	0.70	High
Control	42	72	0.51	Medium

The difference in N-Gain scores between the experimental and control classes can be attributed to the use of gamification-based interactive science media integrated with the Discovery Learning model in the experimental class. This finding aligns with previous research, which has demonstrated that the Discovery Learning model, when supported by interactive media, effectively enhances students' understanding of science concepts, as well as their motivation and comprehension of junior high school physics topics, such as the structure and function of living organisms (Musra, 2024; Toli & Kallery, 2021; Liao et al., 2025). The N-Gain analysis revealed that the highest conceptual understanding in the experimental class occurred in the indicators for providing examples, which were rated at a high level, followed by the explanation indicator. A detailed analysis of N-Gain results per indicator of conceptual understanding is presented in Table 4.

Table 4. N-gain analysis per indicator of conceptual understanding

No	Indicators	N-Gain			
		Experiment	Criteria	Control	Criteria
1	Interpreting	0.73	High	0.65	Medium
2	Exemplifying	0.76	High	0.47	Medium
3	Classifying	0.73	High	0.51	Medium
4	Summarizing	0.70	High	0.11	Medium
5	Comparing	0.72	High	0.49	Medium
6	Explaining	0.65	Medium	0.43	Medium

The Effectiveness of Interactive Media Based on Gamification of The Discovery Learning Model in Increasing Student Creativity

The results of the pretest and posttest on student creativity, as shown in the table, reveal a noticeable difference between the experimental and control classes. The experimental class, which utilized gamification-based interactive science media integrated with the Discovery Learning model, achieved a higher N-Gain than the control class. This indicates that the use of interactive media with the Discovery Learning model effectively enhances student creativity. In line with this, research by Benyamin et al. (2022) and Juniarso (2020) suggests that applying the Discovery Learning model, particularly in inorganic practicum lectures, can foster creativity and improve creative thinking skills among students. A detailed analysis of the pretest and posttest results on student creativity is presented in Table 5.

Table 5. Analysis of pretest and posttest of students' creativity

Class	Pretest Average	Posttest Average	N-gain	Criteria
Experiment	44.33	79.10	0.62	Medium
Control	46.67	62.5	0.29	Low

Indicators of student creativity in the study include fluency thinking, flexibility, originality thinking, and elaboration thinking. Muhammad & Atmojo (2018) fluency thinking skills can be formed through innovative and enjoyable learning in this study using interactive media based on gamification with a discovery learning model where students will be directly involved, conducting experiments. The N-gain results per creativity indicator for the control and experimental classes are shown in Table 6.

Table 6. N-gain results per creativity indicator

No	Indicator	N-Gain			
		Experiment	Criteria	Control	Criteria
1	Fluency	0.59	Medium	0.24	Low
2	Flexibility	0.62	Medium	0.37	Medium
3	Originality	0.57	Medium	0.31	Medium
4	Elaboration	0.72	High	0.25	Low

Habibullah's research (2023) obtained significant results that by implementing discovery learning models, experimental classes can improve creative thinking skills regarding fluency and flexibility. Akmal et al. (2023), Almulla (2023) and Hsia et al. (2021) states that critical thinking will contribute to student creativity and the discovery learning model can help improve creative thinking skills.

CONCLUSION

The interactive science learning media based on gamification and integrated with the discovery learning model was found to be valid, practical, and effective, as indicated by the analysis results. The developed media effectively supported students in enhancing their conceptual understanding and creativity. Through simple experimental activities, students were able to independently explore scientific concepts, facilitating better comprehension and long-term retention. Creativity was further fostered through mind-mapping activities, allowing students to organize and express their conceptual knowledge in a structured manner. Compared to conventional learning approaches, which often result in passive classroom engagement, the use of gamification-based interactive media provided a more engaging and student-centered learning experience. Future studies are encouraged to explore the application of gamification with different instructional models and subject matter to examine its potential across various educational contexts further.

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