

Development of an Interactive E-Module Containing Gamification on the Material of Relations and Functions

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Abstract

This research is motivated by the low motivation and learning outcomes of students on the topic of Relations and Functions, as well as the limited use of technology-based teaching materials at SMP Negeri 2 Mengwi. The purpose of this research is to develop an interactive e-module containing gamification and test its validity, practicality, and effectiveness. This research uses the ADDIE development model consisting of the stages of analysis, design, development, implementation, and evaluation. The product was validated by two experts, while the trial included a limited test and a field test. The validation results show that the developed e-module is very valid both in terms of material and media aspects. Practicality was measured using the User Experience Questionnaire (UEQ), with most aspects rated "very good". In terms of effectiveness, student learning motivation is in the very high category with an average score of 83, and the average learning outcome increased from 68 to 84 after using the e-module. Therefore, the interactive e-module with gamification is considered valid, practical, and effective for use in mathematics learning on the topic of Relations and Functions.

Keywords: gamification, interactive e-module, learning motivation, learning outcomes, relations and functions

1. INTRODUCTION

The rapid advancement of science and technology in the digital era has significantly transformed various aspects of human life, including education. Education plays a crucial role in developing quality human resources. According to Pristiwanti et al. (2022), education is a conscious and planned effort to create a pleasant learning environment so that students can actively develop their potential.

One important subject that needs to be taught in a fun way is mathematics. Learning mathematics, as a basic subject that supports logical and systematic thinking skills, will help students develop good mathematical literacy in problem-solving. However,

in reality, the results of the Program for International Student Assessment (PISA) show that Indonesian students' mathematical literacy remains low. The 2022 PISA report shows that Indonesia ranked 70th out of 81 countries, with an average score of 366, far below the international average (Juliana, 2024). This indicates a gap between expected and actual results.

Many factors contribute to these results, both internal and external to the students. However, in mathematics learning in schools, one thing that can be done is to improve external factors that are expected to influence internal factors. One way to do this is by improving classroom learning strategies. This strategy involves not only trying different models or methods, but also implementing appropriate and modern media.

Observations and interviews conducted at a junior high school in Badung revealed that mathematics learning still relies heavily on printed materials such as textbooks and student worksheets, without the integration of digital learning tools. Learning outcomes for the topic of Relations and Functions showed that more than 50% of students scored below the Minimum Completion Criteria (KKTP). Mathematics learning is conducted conventionally without digital media, resulting in low student motivation to learn mathematics. Therefore, efforts are needed to address this problem in line with current developments.

One way to achieve this is through the strategic use of digital learning media. Teachers can utilize learning media to deliver mathematical concepts more effectively (Erawati et al., 2025). Research shows that integrating digital tools such as interactive e-modules improves conceptual understanding, motivation, and student engagement. A study by Rochsun & Agustin (2020) developed a contextual problem-based mathematics e-module at the junior high school level. The module was proven valid and appropriate, and students who used it achieved significantly higher post-test scores, as well as effective learning in set theory.

Learning in the digital era should utilize technology as a supporting tool. One such innovation is interactive e-modules. Herawati and Muhtadi (2018) argue that e-modules offer a flexible learning experience that can be accessed anytime and anywhere, supported by multimedia features that enhance conceptual understanding. A quality e-module should include video, images, audio, navigation, and practice questions (Maharcika, 2021; Deliany & Nurhayati, 2019). Furthermore, Amril and Thahar (2022) demonstrated that interactive e-modules significantly improved students' conceptual understanding.

Similarly, the development of interactive e-modules with computational thinking features has demonstrated high validity, practicality, and effectiveness. Putra, Suparta, & Sudiarta (2025) developed an e-module for high school mathematics using Moodle integrated with H5P and Scratch. This module met expert validation and significantly improved mathematics problem-solving. Furthermore, more controlled experimental studies support the positive impact of gamification. Önder Karamert & Kuyumcu Vardar (2021) implemented gamification in fifth-grade mathematics learning (fractions). The results showed a statistically significant increase in achievement in the gamified group compared to the control group. Furthermore, research by Nursyaida & Samad (2024) demonstrated that combining gamified e-modules with HOTS-oriented content can produce strong learning outcomes.

Asrial et al. (2019) emphasized that integrating technology into education is a crucial response to 21st-century demands, which encompass not only content mastery but also innovation and learning skills. However, the use of e-modules alone may not be sufficient to increase student motivation. Gamification is a promising approach that can increase engagement and motivation through game-like elements. Glover (2013) explained that gamification offers advantages. Hendri and Feliks (2021) found that gamification supports emotional, cognitive, and behavioral engagement. Similarly, Zahara (2021) stated that gamified learning media increases students' attention and enthusiasm for learning.

In mathematics education, gamification can create a fun and competitive learning experience, helping reduce student boredom and improve conceptual mastery (Yulis Tyaningsih, 2022). Srimuliyani (2024) also confirmed that gamification significantly increases student motivation and participation in class. Therefore, integrating interactive e-modules and gamification is an ideal strategy for improving the quality of mathematics learning. The application of appropriate learning strategies and media is expected to foster student motivation in mathematics. Fatimah (2023) found that one of the causes of low student learning motivation is the limited use of digital learning media that aligns with current technological developments.

Based on the explanation of the implementation of strategies and media, it can be used to increase student learning resources and create a more enjoyable learning environment, thereby increasing student motivation in mathematics, which is expected to also lead to better learning outcomes. Therefore, innovations are needed to simultaneously address both challenges, one of which is the creation of electronic modules containing gamification. This innovation is considered necessary and important because learning resources in the form of electronic modules or e-modules can facilitate students' learning anywhere and anytime. This means students can review material learned at home. Gamification is added as an effort to motivate students to study these e-modules. Gamification is an appropriate step to utilize the facilities available to each student, namely every student's gadget. Through gadgets, students learn while playing. This gamified e-module is also designed to be interactive, preventing boredom and instead challenging students.

This research tries to fill in the research gap explained above by developing an interactive e-module equipped with gamification features to teach Relationships and Functions. This module combines digital content and game elements through platforms such as Wordwall and Flip PDF Professional, and is designed to support the National Curriculum. This innovation is expected to increase student engagement, motivation, and learning outcomes.

2. LITERATURE REVIEW

The development of technology-based learning media has become a widely studied strategy to improve the effectiveness of learning in the digital era. E-modules are one form of digital teaching material that allows students to learn independently, flexibly, and interactively. According to Herawati and Muhtadi (2018), e-modules have the potential to enhance conceptual understanding as they combine text, images, videos, audio, and interactive navigation features that facilitate student engagement. Furthermore, e-modules support student autonomy as they can be accessed anytime and anywhere (Laili, 2019). In the context of mathematics education, e-modules play a critical role given the

abstract nature of mathematical concepts, which are often difficult for students to grasp. Maharcika (2021) emphasized that visually rich and interactive e-modules help simplify complex mathematical content, including the topic of relations and functions. Amril and Thahar (2022) also found that the use of interactive e-modules positively impacts students' conceptual understanding by offering well-structured and engaging content.

Meanwhile, gamification has emerged as a promising pedagogical approach to increase students' motivation and engagement in the learning process. Glover (2013) explains that gamification involves incorporating game elements, such as points, levels, and challenges into learning environments to make the experience more enjoyable. Hendri and Feliks (2021) note that gamification supports cognitive, affective, and behavioral engagement among students. In mathematics learning, gamification helps reduce anxiety and boredom, while encouraging active participation in problem solving (Zahara, 2021). Fatimah (2023) demonstrated that gamified e-modules are more effective than conventional ones in improving students' learning outcomes. This is supported by Srimuliyani (2024), who found that incorporating game mechanics into learning media significantly enhances student motivation and participation.

Learning outcomes are a change in behavior shown by students after undergoing a learning process. Evaluatively, learning outcomes cover three main domains: cognitive (mastery of concepts, logic, knowledge), affective (attitude, interest, motivation), psychomotor in the form of operational skills (Nurhasnah, et al, 2023). Factors that influence student learning are (Lestari et al, 2023) : (1) Factors from within the student in the form of the physical and spiritual condition of the student himself. (2) Factors from outside the student in the form of environmental conditions around the student. (3) Strategies or methods used by students in order to study and understand learning materials.

Learning motivation is the overall psychological process that explains why students initiate, maintain, or stop learning activities, including goals, perceived task value, sense of competence, and internal regulation (intrinsic/extrinsic). Motivation is not a single entity, but rather multi-layered and changing over time. (Törmänen et al, 2025). Many factors influence motivation. Ruos et al. (2025) stated that teaching behaviors such as teacher autonomy support, feedback that supports competence, and setting valuable/interesting tasks can increase motivation. Johanses et al. (2023) stated that task contexts such as relevance, appropriate challenges, and goal clarity increase vitality and motivation. Bureau et al. (2021) stated that social and cultural conditions such as classroom norms, peer/family support, and assessment practices influence motivational orientation. Based on these factors, one can choose one that is possible to implement according to the characteristics of the student and their learning environment.

3. RESEARCH METHODOLOGY

3.1. Research Design

This study is a research and development (R&D) study using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it provides a systematic framework for the development of learning products, starting from needs analysis to product refinement based on evaluation results. This model is considered

Ni Kadek Yuliastini et al., *Development of an Interactive E-Module Containing Gamification* suitable for developing educational media such as interactive e-modules that require ongoing validation and improvement.

3.2. Participants of the Study

The research was conducted at SMP Negeri 2 Mengwi, located in Badung Regency, Bali Province, during the academic year 2024/2025. Participants in this study were eighth-grade students. The selection of the school and participants was done purposively, considering the fact that the school had not yet implemented gamification-based interactive e-modules in mathematics instruction. In the limited trial phase, 6 students were involved, while the field trial phase involved 31 students.

3.3. Instruments

The data collection instruments used in this study included observation sheets, interview guidelines, expert validation sheets, motivation questionnaires, and learning achievement tests. The validation sheets were distributed to media and content experts to assess the validity of the e-module. Motivation questionnaires were given to students after using the e-module to measure its influence on learning motivation. Meanwhile, the achievement tests were used to evaluate the effectiveness of the e-module in improving student performance on the topic of relations and functions.

3.4. Data Analysis Techniques

The data in this study were analyzed using both qualitative and quantitative methods to evaluate the validity, practicality, and effectiveness of the developed interactive e-module with gamification.

3.4.1 Validity of the E-Module

Content validity was assessed through expert judgments using a rubric completed by two validators: a subject matter expert and a media expert. The validation instrument covered aspects such as content accuracy, instructional design, language usage, and technical feasibility.

The analysis followed Gregory's (2000) formula, which quantifies expert agreement on the relevance of the content. The validation process included: (1) Each item was rated on a 4-point scale (1 to 4). (2) Scores of 1 and 2 were categorized as "less relevant," while scores of 3 and 4 were categorized as "highly relevant." (3) The results were tabulated into a cross-validation matrix in Table 1.

Table 1: Cross Tabulation Matrix Based on Gregory's Formula

Validator 1 / Validator 2	Less Relevant	Highly Relevant
Less Relevant	A	B
Highly Relevant	C	D

The validity index was calculated using the formula:

$$(V_r) = \frac{D}{A+B+C+D} \text{ Where:}$$

V_r = Validity indeks

D = Number of items rated the same by both validators

A, B, C = Number of items rated differently

Gregory's validity classification is shown in Table 2.

Table 2: Validity Interpretation Criteria Based on Gregory

No	Range	Validity Category
1	0.80 – 1	Very High
2	0.60 – 0.79	High
3	0.40 – 0.59	Moderate
4	0.20 – 0.39	Low
5	0.00 – 0.19	Very Low

An e-module is considered valid if the calculated validity index is at least 0.60 (High). If the index falls below this threshold, revisions are necessary to align the content and design with instructional standards.

3.4.2 Practicality of the E-Module

The practicality of the e-module was analyzed based on students' responses using the User Experience Questionnaire (UEQ), administered after the learning sessions. The analysis utilized the UEQ Data Analysis Tool (Version 12) following these steps: (1) Converting raw scores into standard UEQ scale values. (2) Identifying inconsistent responses (outliers), particularly those with large score differences (more than three). (3) Calculating the average scale scores for each aspect. (4) Interpreting the results based on six UEQ dimensions: attractiveness (general impression of the product whether users like or dislike it), perspicuity (ease of understanding and learning how to use the product), efficiency (ability to complete tasks without unnecessary effort), dependability (Feeling of control and reliability in using the product), stimulation (enjoyment and motivation generated by the product), novelty (perception of the product's creativity and innovation).

Each dimension contains specific item pairs. For example:

A product is considered practical if most dimensions achieve at least the "Good" category. Dimensions falling into the "Bad" category indicate areas that require revision to enhance usability.

3.4.3 Effectiveness of the E-Module

3.4.3.1 Learning Motivation Questionnaire

Learning motivation was assessed using a Likert-scale questionnaire administered after students used the gamified e-module. The total score was calculated as follows:

$$\text{Motivation Score} = \frac{\text{Total obtained score}}{\text{Maximum possible score}} \times 100\%$$

The interpretation used the Ideal Mean (Mi) and Ideal Standard Deviation (SDi), calculated as:

$$Mi = \frac{\text{Max score} + \text{Min score}}{2}, \quad SDi = \frac{\text{Max score} - \text{Min score}}{6}$$

Motivation category interpretation is shown in Table 3.

Table 3: Motivation Score Interpretation Scale

No	Interval	Category
1	80 < x ≤ 100	Very High
2	66.67 < x ≤ 80	High

3	$53.33 < x \leq 66.67$	Moderate
4	$40 < x \leq 53.33$	Fair
5	$20 < x \leq 40$	Low

A product is considered effective in increasing motivation if the average score falls into the “High” or “Very High” category.

3.4.3.2 Learning Achievement Test

Effectiveness in terms of learning outcomes was determined by students’ mastery of the material, based on the Minimum Mastery Criteria (KKTP) at SMP Negeri 2 Mengwi, which was set at a minimum score of 62.

Classical completeness was calculated using the formula:

$$\text{Mastery Percentage} = \frac{\text{Number of students who passed}}{\text{Total number of students}} \times 100\%$$

4. RESULTS

This section presents the results of the research based on three main criteria: validity, practicality, and effectiveness of the developed interactive e-module with gamification on the topic of Relations and Functions.

4.1 Validity of the E-Module

The validity of the e-module was assessed by two validators. Both validators checked the validity of the initial product using a validation rubric that evaluated content accuracy, instructional design, language use, and technical feasibility. The validation results were analyzed using the Gregory formula. The result of validation score from validators are shown in Table 4.

Table 4: Expert Validation Results of the E-Module

Evaluated Aspect	Validator 1	Validator 2	Agreement (D)	Total Cases (A+B+C+D)	Validity Index (Vr)
Content	Yes	Yes	4	4	1.00
Media	Yes	Yes	4	4	1.00

The calculated validity index for both aspects was 1.00, which falls under the “Very High” category, indicating that the e-module is valid and feasible for use without major revisions.

4.2 Practicality of the E-Module

The practicality of the e-module was evaluated during two stages: limited testing and field testing. The instrument used was the User Experience Questionnaire (UEQ), which measures six aspects: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty.

4.2.1 Practicality in Limited Testing

The limited trial involved 6 students. The average scores for each aspect are presented in the Table 5.

Table 5: Practicality Results of the E-Module (Limited Testing)

UEQ Aspect	Average Score	Category
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Attractiveness	1.70	Excellent
Perspiciuity	1.43	Excellent
Efficiency	1.50	Excellent
Dependability	1.49	Excellent
Stimulation	1.60	Excellent
Novelty	1.55	Excellent

4.2.2 Practicality in Field Testing

The field trial involved 31 students. The results are presented in the Table 6.

Table 6: Practicality Results of the E-Module (Field Testing)

UEQ Aspect	Average Score	Category
Attractiveness	1.73	Excellent
Perspiciuity	1.50	Excellent
Efficiency	1.57	Excellent
Dependability	1.52	Excellent
Stimulation	1.65	Excellent
Novelty	1.60	Excellent

All aspects were categorized as Excellent, both in limited and field testing, showing that the e-module is highly practical and user-friendly.

4.3 Effectiveness of the E-Module

Effectiveness was evaluated using two indicators, there are student motivation and learning outcomes.

4.3.1 Student Motivation

Student motivation was measured using a Likert-scale questionnaire administered after the use of the e-module. Table 7 shown of motivation score of the students.

Table 7: Student Learning Motivation Scores

Testing Stage	Number of Students	Average Score	Category
Limited Trial	6	81	Very High
Field Trial	31	83	Very High

The results show that students demonstrated very high learning motivation after using the e-module in both trials.

4.3.2 Student Learning Outcomes

Learning outcomes were assessed by comparing pretest and posttest scores on the topic of Relations and Functions. Table 8 shown of Student Learning Outcomes.

Table 8: Student Learning Outcomes

Testing Stage	Number of Students	Pretest Average	Posttest Average	Gain
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Limited Trial	6	67.50	82.00	14.50
Field Trial	31	68.00	84.00	16.00

The increase in average scores indicates a significant improvement in students' understanding, demonstrating that the e-module is effective for learning the topic of Relations and Functions.

5. DISCUSSION

The research results indicate that this e-module is considered highly feasible and relevant for use in the learning process. This is due to the systematic development process, which followed the established development model stages, starting with needs analysis, design, gamification-based content development, and testing. This process was carried out in accordance with the principles of good learning tool development, such as clarity of objectives, alignment of material with the curriculum, and integration between pedagogical and technological aspects.

The validators provided several minor suggestions for improvements related to visualization and navigation to make the module more engaging and interactive. This feedback was then used as the basis for product revisions before proceeding to the testing phase. This demonstrates a reflective and iterative process in product development, strengthening the validity of the final result. Overall, the validity scores for the material and media aspects indicate that the developed interactive e-module meets the standards for appropriateness of content, presentation, and use of interactive media in mathematics learning. This aligns with Sukardi's opinion (in Sari et al., 2021), who stated that a learning tool is considered valid if it is developed according to procedures, receives valid assessments from experts, and is recommended for use.

Furthermore, feedback from students also supported the practicality of the developed product. Based on interviews, students found the e-module easy to use, attractive in appearance, and easy to understand. The use of gamification elements was considered to make the learning process more enjoyable and less boring, and helped them grasp the material more quickly and independently.

The interactive aspect of this e-module encouraged students to participate more actively in the learning process. This interactivity transformed students into subjects directly involved in exploring the material, completing challenges, and receiving immediate feedback. This resulted in increased independence, curiosity, and overall learning engagement.

These responses indicate that the e-module is not only easy to use but also effective in providing a positive and interactive learning experience. This aligns with Nieveen's opinion (in Rahayu & Hernadi, 2020), who stated that a learning tool can be considered practical if it is easy for the target user to use and contributes to the smoothness and quality of the learning process.

Thus, the interactive e-module containing gamification that has been developed has met the criteria of practicality, because it is capable of being used independently by students, is visually and content attractive, and provides a learning experience that is fun, meaningful, and encourages active involvement in the learning process. The implementation of e-modules designed with gamification elements has been proven to increase student learning motivation. Based on data from a learning motivation

questionnaire consisting of 20 statements, the average score reached 83, which is considered very high. This indicates that e-modules encourage student interest, engagement, and active participation in learning.

Factors that contribute to this increased motivation include interactive presentation of material, the use of engaging visual media, and the inclusion of gamification elements such as quizzes and tiered challenges. This makes the learning process enjoyable, challenging, and less monotonous. Students feel more engaged and motivated to complete each section of the material because e-modules provide a learning experience that differs from conventional learning.

Positive feedback from students supports this finding. Students stated that e-modules help them learn in a more enjoyable and less boring way. The attractive layout, easy navigation, and interactive challenges make learning more lively and meaningful. In line with the research findings of Akhmadi (2025), gamification-based learning media can increase learning motivation because they create a more engaging, competitive learning environment and stimulate students' curiosity.

The findings of this study, which demonstrate that the interactive e-module with gamification is valid, practical, and effective in increasing both motivation and learning outcomes, are consistent with and further strengthen evidence reported in at least five relevant studies. First, the significant motivation gains (average score = 83) align with Zahara (2021), who found that gamification increases student attention and enthusiasm for learning. Second, similar to Fatimah (2023), this study confirms that gamified digital learning media outperform conventional approaches in influencing both motivation and achievement. Third, the increasing post-test scores on Relations and Functions validate conclusions by Karamert & Kuyumcu Vardar (2021) that gamification produces a statistically higher mathematics performance compared to standard instruction. Fourth, the practicality results rated "Excellent" across all UEQ dimensions are in line with Hendri & Feliks (2021), who emphasized usability and behavioral engagement as keys to successful gamified e-learning. Fifth, this research supports the work of Nursyaida & Samad (2024), which showed that interactive gamified e-modules can foster higher-order thinking and improve overall learning effectiveness. Collectively, these converging findings confirm that combining interactivity and game mechanics creates a more enjoyable, engaging, and pedagogically impactful learning environment for mathematics students.

6. CONCLUSION

This study concludes that the interactive gamification e-module for Relations and Functions is valid, practical, and effective. The results of the product's validity, practicality, and effectiveness are supported by the development steps that followed proper procedures. Furthermore, the suitability of the needs and objectives to be achieved can be implemented in the product design. The interactions that occur are very visible in the games contained in the e-module. Therefore, this e-module can be used as an innovative alternative in mathematics learning and can be implemented to support a student-centered curriculum in the digital era. In the future, it is hoped that e-modules can be developed in other materials and tested more widely.

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