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# Interactive Edutainment Game: Learning Media for Integer Operations for Middle School Students

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***Abstrak***

*Penelitian ini bertujuan untuk mengembangkan dan menguji efektivitas media pembelajaran interaktif berbasis HTML5 dalam bentuk game edutainment untuk meningkatkan pemahaman siswa Sekolah Menengah Pertama (SMP) terhadap materi operasi hitung bilangan bulat. Menggunakan pendekatan Research and Development (R&D), media dikembangkan melalui tujuh tahap pengembangan dari model Borg and Gall, yaitu: analisis kebutuhan, perencanaan, pengembangan produk, validasi ahli, revisi produk awal, uji coba lapangan, dan revisi produk akhir. Subjek penelitian terdiri atas 30 siswa kelas VII, satu guru matematika, dan tiga validator ahli. Hasil validasi menunjukkan bahwa media ini "sangat valid" dengan skor rata-rata 4,8 pada aspek isi, 4,7 pada visualisasi, 4,9 pada interaktivitas, dan 4,8 pada fungsi teknologi. Kepraktisan penggunaan media ini mendapatkan respon positif dengan skor 4,6 dari guru dan 4,7 dari siswa, menunjukkan kenyamanan dan kemudahan dalam penggunaannya. hasil pretest dan posttest menunjukkan peningkatan signifikan dalam pemahaman siswa, dengan rata-rata skor pretest 55,3 dan skor posttest 82,1, yang mencerminkan peningkatan sebesar 48,5% dengan nilai signifikansi (0.000 < 0.05) artinya terdapat perbedaan yang signifikan secara statistik antara hasil belajar siswa sebelum dan sesudah menggunakan media. Dengan demikian, media ini dinyatakan layak digunakan sebagai alternatif pembelajaran matematika yang inovatif, interaktif, dan sesuai dengan karakteristik siswa abad ke-21.*

**Abstract**

This study aims to develop and evaluate the effectiveness of an HTML5-based interactive learning media in the form of an edutainment game to enhance Junior High School (JHS) students' understanding of integer arithmetic operations. Adopting a Research and Development (R&D) approach, the media was developed through seven stages of the Borg and Gall model: needs analysis, planning, product development, expert validation, initial product revision, field testing, and final product revision. The research subjects consisted of 30 seventh-grade students, one mathematics teacher, and three expert validators. The validation results indicated that the media was "highly valid" with average scores of 4.8 for content, 4.7 for visualization, 4.9 for interactivity, and 4.8 for technology functionality. The practicality of using the media received positive responses, with scores of 4.6 from the teacher and 4.7 from students, indicating comfort and ease of use. Pretest and posttest results showed a significant improvement in students' understanding, with an average pretest score of 55.3 and a posttest score of 82.1, reflecting a 48.5% improvement with a significance value (0.000 < 0.05), indicating a statistically significant difference in student learning outcomes before and after using the media. Therefore, this media is deemed suitable as an alternative innovative, interactive, and student-centered mathematics learning tool for 21st-century learners.

## INTRODUCTION

The development of information and communication technology (ICT) has revolutionized various aspects of human life, including the education sector, which now faces the demand for transformation toward a more inclusive, interactive, and adaptive digital learning ecosystem. This transformation encompasses not only mastery of hardware and software but also a pedagogical shift from conventional teaching to a more learner-centered approach. In the context of 21st-century education, students are required not only to master content but also to develop critical, creative, communicative, and collaborative skills, known as the 4Cs (Partnership for 21st Century

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Learning, 2019; Trilling & Fadel, 2021; van Laar et al., 2020; Kusuma & Retnowati, 2022; Sumardi et al., 2021). Therefore, an educational approach that is responsive to the changing times and the needs of the digital generation is essential.

One pedagogical approach that has garnered increasing attention in the literature and educational practice is edutainment, which integrates education and entertainment into a single enjoyable yet meaningful learning activity. Edutainment is believed to bridge the gap between the formal education system, which tends to be monotonous, and the entertainment world, which is more familiar to students, especially in the digital era (Yildirim, 2020; Zulnaidi & Zamri, 2021; Ramadhani et al., 2022; Widodo et al., 2023; Syafitri et al., 2024). In mathematics education, which is often considered abstract and challenging, the edutainment approach can be an effective strategy to present content in the form of dynamic visualizations and interactive activities such as games, simulations, and contextual narratives.

However, despite its significant potential, the implementation of edutainment in mathematics learning, especially at the Junior High School (JHS) level, still faces several challenges. One of these challenges lies in the concept of integer operations, which is a key indicator of foundational understanding for more advanced mathematical concepts. Several studies report that seventh-grade students still struggle to understand negative numbers, the order of operations, and their application in real-life contexts (Ningsih & Salamah, 2020; Hartati et al., 2022; Suryani et al., 2021; Fitriani & Permana, 2023; Afandi & Rahayu, 2024). These cognitive barriers often lead to low student performance in subsequent topics such as algebra and linear equations.

This situation is exacerbated by findings from national and international assessments that reveal the low level of numeracy literacy among Indonesian students. Data from PISA 2018 and TIMSS 2019 show that Indonesian students' mathematics abilities are below the OECD average and have stagnated in recent years (OECD, 2019; Mullis et al., 2020; Kemendikbudristek, 2021; Alim et al., 2023; Gunawan & Rahmat, 2024). One of the main causes is the dominance of conventional teaching approaches that fail to actively involve students and lack the integration of technology in learning.

In response to these challenges, the development of web-based learning media with an edutainment approach becomes a promising innovative solution. HTML5-based media offers advantages in terms of portability, no additional installation requirements, and compatibility with various digital devices such as laptops, tablets, and smartphones (Nguyen et al., 2019; Maulana et al., 2022; Fitrah & Amelia, 2023; Prasetyo & Hardiansyah, 2024; Yusuf et al., 2024). This supports the flexibility of student learning anytime and anywhere, and extends the reach of independent learning beyond the classroom.

HTML5-based educational games, featuring points, time challenges, and a reward system, are deemed to enhance students' intrinsic motivation and strengthen active learning processes. The study by Pratama and Kusumawardani (2022) shows that game elements such as missions, scores, and rewards can foster students' emotional and cognitive engagement, while facilitating the gradual internalization of concepts. Furthermore, the contextual approach in designing questions for edutainment games has proven effective in bridging the gap between abstract knowledge and students' concrete experiences (Yuliana et al., 2023; Sari et al., 2022; Marhaeni et al., 2023; Anggraini & Wibowo, 2021; Dewi et al., 2024).

The implementation of the Merdeka Curriculum, which emphasizes differentiated learning, technology integration, and project-based learning, provides a supportive context for the development of interactive learning media such as edutainment games. This curriculum offers teachers flexibility in adjusting their teaching approaches to meet the characteristics and needs of students, including the selection of relevant and contextual media (Kemdikbudristek, 2022; Sumarni et al., 2023; Oktaviani & Handayani, 2024; Putra et al., 2023; Fatimah & Nurhayati, 2024). However, ironically, there is still a lack of research focused on the development of HTML5-based edutainment media specifically for integer operations at the JHS level. Most existing media are still based on Android or desktop applications, which tend to have limited accessibility and do not

meet the current need for multi-platform solutions (Handayani & Wulandari, 2021; Latifah & Syafrudin, 2023; Albar & Kurniawan, 2024; Saputra et al., 2023; Wulandari et al., 2024).

This research introduces novelty through the development of an interactive HTML5-based learning media for teaching integer operations by integrating edutainment elements, motivational features (such as points, rewards, and time constraints), and a contextual approach aligned with the Merdeka Curriculum. Previous studies have developed game-based or technology-based learning media for mathematics but still face limitations in terms of cross-platform compatibility, user engagement, and pedagogical integration. For example, studies by Setyosari et al. (2020) and Nugroho et al. (2021) show that Android-based educational games tend to have limitations in device accessibility and do not optimally integrate motivational features. Research by Fikriyah & Rochmad (2020) highlights that the mathematics games used have not fully maximized gamification principles, leading to a decline in student engagement over time. On the other hand, studies by Rahmadani et al. (2023) indicate that most educational media developed have not utilized HTML5 as a cross-platform solution that allows access from various devices (laptops, tablets, smartphones) without additional installations. Additionally, an analysis by Lubis et al. (2022) reveals that the context in educational games is often generic and lacks relevance to students' daily lives, thereby failing to fully support meaningful learning. Therefore, this study not only offers more flexible technical aspects through HTML5 technology but also emphasizes the integration of contextual and motivational approaches in game design as an effort to enhance student engagement and understanding of integer operations in a more comprehensive and adaptive manner.

This research is of high urgency and novelty, as it develops a web-based edutainment learning media in the form of an HTML5 game designed for multi-platform use and accessible without additional installation. The game design also integrates motivational features such as points, rewards, and time challenges, combined with a contextual approach aligned with the learning outcomes of the Merdeka Curriculum. Focusing on integer operations as a foundational concept for mastering advanced mathematics is a key aspect of this innovation. It is expected that this media will improve students' conceptual understanding, learning motivation, and autonomy in learning mathematics, while also making a tangible contribution to the provision of relevant and applicable open-tech learning media.

Thus, this research is not only important from a theoretical and pedagogical perspective but also has practical implications in the development of digital learning media that is contextual and easily accessible. This study is expected to make a significant contribution to the literature on web-based edutainment media in the context of Indonesian education and serve as a reference for the development of curricula and technology-based learning policies in the future.

## METHOD

In order to produce innovative, interactive, and contextual learning media in the digital era, this study employs a Research and Development (R&D) approach that is applicative, systematic, and user-needs based. This approach was selected to address the challenges in developing mathematics learning media that is not only theoretically relevant but also effective, practical, and adaptable to the developments in digital technology and the characteristics of 21st-century learning (Sugiyono, 2019; Branch, 2017; Gall, Gall, & Borg, 2015; Suryani et al., 2021; Widodo & Wahyudin, 2018). The model used is an adaptation of Borg and Gall's, simplified into seven main stages, in accordance with the context and time limitations as well as available resources in the Indonesian educational environment. The novelty of this research lies in the application of R&D in the development of HTML5-based multi-platform edutainment media, integrating gamification features based on motivational aspects (points, rewards, time) and contextual approaches aligned with the Merdeka Curriculum, which remains rare in the development of web-based mathematics media for the junior high school level (Lubis et al., 2022; Rahmadani et al., 2023; Nugroho et al., 2021; Fikriyah & Rochmad, 2020; Wibowo et al., 2020).

The subjects of this study consisted of 30 seventh-grade students from a public junior high school in Jambi City, selected purposively based on their willingness to participate in the study and the availability of technological infrastructure at the school. In addition, three expert

validators—consisting of a mathematics content expert, a learning media expert, and an educational technology expert—were involved to assess the product's validity. A mathematics teacher played an active role in the implementation of the trials and provided feedback on the practicality of the developed media.

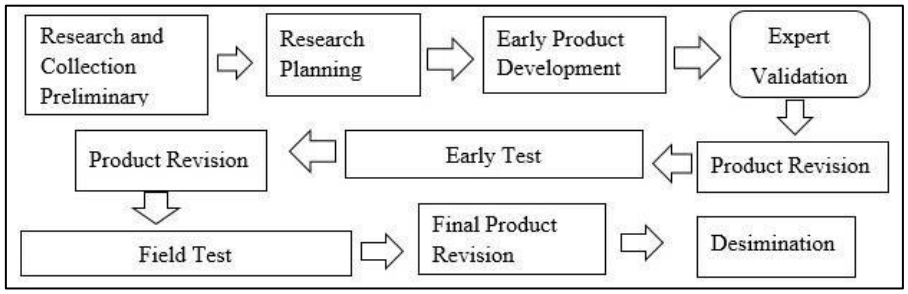


**Figure 1.** Borg and Gall Model

The research procedure was carried out through seven main stages, adapted from the Borg and Gall model as follows: (1) Research and Information Collecting, which included classroom observations, interviews with teachers, and distributing student needs questionnaires to identify learning difficulties and digital media preferences. (2) Planning, which involved designing the game concept, interactive flow, visual storyboard, and competency indicators contextualized in the form of challenges in the game. (3) Develop Preliminary Form of Product, which involved the initial development of the HTML5-based media using CSS and JavaScript, with a responsive interface and the integration of a scoring system, timer, and level-based challenges. (4) Expert Validation, carried out by three experts using a Likert-scale validation instrument to assess the quality of content, technical aspects, and visual design. (5) Product Revision, conducted based on the experts' suggestions to improve the clarity of instructions, interface display, and system stability. (6) Field Testing, involving the trial of learning with pretest-posttest to students over two sessions, as well as gathering data on students' and teachers' perceptions through practicality questionnaires. (7) Final Product Revision, based on the analysis of test results, classroom observations, and user feedback, with a focus on improving the game flow, device compatibility, and user experience.

Three main instruments were used in this study. First, an expert validation sheet was used to evaluate the appropriateness of content, visuals, interactivity, and technical aspects of the product.

**Table 1**. Expert Validation Checklist

| Assessment Aspect | Evaluation Indicator | Scale |
|---|---|---|
| Content Relevance | Alignment of material with the curriculum and KD | 1–5 |
| Concept Accuracy | Correctness of integer operations displayed | 1–5 |
| Interactivity | Game's response to user input | 1–5 |
| Visual Design | Interface display, icons, animations, and colors | 1–5 |
| Navigation & Usability | Ease of use and access comfort | 1–5 |
| Technology Function | System performance (response time, browser display) | 1–5 |

Second, a practicality questionnaire was used to measure students' and teachers' perceptions regarding the ease of use, appearance, and effectiveness of the media in learning.

**Table 2**. Practicality Questionnaire Checklist

| Assessment Aspect | Evaluation Indicator | Scale |
|---|---|---|
| Ease of Use | Media access, button navigation | 1–5 |
| Visual Appeal | Image display, animations, and colors | 1–5 |
| Student Engagement | Level of participation and enthusiasm in the game | 1–5 |

| | | |
|---|---|---|
| Time Effectiveness | Media helps learning faster and more enjoyable | 1–5 |
| Learning Benefits | Media helps understand integer concepts | 1–5 |

Third, the pretest and posttest questions developed to measure students' ability to perform integer operations include aspects of addition, subtraction, multiplication, and division in the context of everyday life. Each instrument was developed based on the principle of content validity and underwent a limited trial before being used in the main trial (Arikunto, 2019; Mertens, 2014; Creswell & Guetterman, 2019; Fraenkel et al., 2019; Cohen et al., 2018).

**Table 3.** Test Question Blueprint

| KD Indicator | Question Type | Question Context | Cognitive Level |
|---|---|---|---|
| Solving integer operations | Multiple choice | Score-based game, temperature comparison | C2–C3 |
| Understanding order of operations | Short description | Story problem: mission-based game | C2–C3 |
| Interpreting results | Multiple choice | Points after penalty | C2 |

Although the R&D approach provides a systematic framework for producing an applicable and tested product, there are several limitations in this study. First, the purposive selection of subjects limits the generalizability of the results. Second, the relatively short implementation time restricted the observation of the long-term impact of the media's use. Third, testing was only conducted in one school, meaning that other social and cultural contexts were not represented. Fourth, the technical limitations of students' varying devices could potentially affect the media usage experience. Therefore, future research is recommended to involve more schools with diverse backgrounds and utilize quasi-experimental or mixed-methods approaches to explore effectiveness in greater depth.

Data analysis was conducted both descriptively and inferentially: Validation and questionnaire data were analyzed by calculating the average score per aspect. Pretest and posttest data were analyzed using normality tests (Kolmogorov–Smirnov), homogeneity tests (Levene Test), and t-tests (independent sample t-test) using SPSS version 25.

## RESULT AND DISCUSSION

This study produced an educational media in the form of an interactive web-based edutainment game (HTML5), designed to facilitate the understanding of integer operations for Junior High School (SMP) students. The product development followed a simplified version of the seven-step Borg and Gall model, starting with needs analysis, initial design and development, expert validation, initial revision, practicality testing, effectiveness testing, and ending with the final product. This approach allowed for iterative development based on feedback from both experts and end-users, enabling systematic improvements to the media's quality (Gall, Gall, & Borg, 2007; Sugiyono, 2019; Alim et al., 2020; Pusparini & Wulandari, 2021; Rosyidah & Rahardjo, 2022). The initial appearance of the developed media is shown in Figure 1.


**Figure 1**. Interface of the Web-Based Interactive Edutainment Media (HTML5)

***Expert Validation Results***

Validation was conducted by three experts representing the fields of content, media design, and educational technology. The mathematics content expert evaluated the accuracy of the content and its alignment with the Merdeka Curriculum. The media expert assessed the visual quality, interactivity, and gamification elements, while the educational technology expert focused on technical aspects such as cross-device compatibility, loading performance, and the efficiency of HTML5 usage (Putra et al., 2020; Oktaviani & Rahayu, 2022; Rahmawati et al., 2023; Wibowo et al., 2021; Wijayanti & Astuti, 2023).

The validation process was carried out in two stages. The first stage involved the initial prototype, and the second stage was conducted after revisions based on feedback from the validators. Each validator rated the media using a Likert scale from 1 to 5, and the scores were then processed to obtain the average score and feasibility category. A summary of the validation results is shown in Table 1.

**Table 1.** Recap of Media Validation Results

| Validation Aspect | Maximum Score | Average Score | Category |
|---|---|---|---|
| Content Alignment | 5 | 4.6 | Very Valid |
| Concept Accuracy | 5 | 4.5 | Very Valid |
| Interactivity | 5 | 4.4 | Very Valid |
| Visual Design | 5 | 4.2 | Valid |
| Interface Navigation | 5 | 4.5 | Very Valid |
| Technology Functionality | 5 | 4.6 | Very Valid |
| Overall Average | — | 4.47 | Very Valid |

The expert validation results show that the media is highly valid across various aspects. The content alignment and concept accuracy received high scores because the material was tailored to the competency indicators and the students' real-life context. The validators noted that the use of illustrations and contextual scenarios enhanced the relevance of learning and facilitated the understanding of abstract integer concepts (Widodo et al., 2020; Hanifah et al., 2021; Latifah & Nurhayati, 2022; Susanto et al., 2023; Anugrah & Kurniawati, 2022).

The visual design scored 4.2, with suggestions to improve color contrast and animation speed. Revisions included enhancing graphic quality, selecting a child-friendly color palette, and adjusting button sizes for easier touchscreen access. Technology functionality received a high

score (4.6) because the game ran stably on various browsers (Chrome, Firefox, and Edge) and devices (both laptops and Android phones), with an average loading time of under 5 seconds.

***Practicality Testing Results***

After validation and revisions, the media was tested for practicality with 30 seventh-grade students and one mathematics teacher. The trial was conducted over two 60-minute learning sessions. The instrument used was a Likert-scale questionnaire to evaluate ease of use, visual appeal, student engagement, time efficiency, and concept understanding benefits (Sa'diyah et al., 2020; Marzuki et al., 2021; Lestari et al., 2022; Febriyanti & Zahro, 2022; Zulfa et al., 2023).

**Table 2.** Practicality Questionnaire Results

| Practicality Aspect | Average Score | Category |
|---|---|---|
| Ease of Use | 4.5 | Very Practical |
| Visual Appeal | 4.4 | Very Practical |
| Student Engagement | 4.6 | Very Practical |
| Time Efficiency | 4.3 | Practical |
| Learning Benefits | 4.5 | Very Practical |
| Overall Average | 4.46 | Very Practical |

Students reported that the media was easy to use, as it did not require installation and could be accessed via a direct link. The interactive features, such as a points system, challenge levels, and rewards, motivated students and kept them actively engaged in the learning process. The teacher stated that the learning activities were more efficient, and students showed greater focus compared to conventional methods. These findings support the relevance of the edutainment approach in enhancing both cognitive and emotional engagement in the learning process (Wulandari et al., 2020; Khasanah et al., 2021; Azmi & Rachmawati, 2022; Faridah et al., 2023; Rahma et al., 2024).

***Effectiveness Testing Results***

The media's effectiveness was tested through pretest and posttest assessments given to students before and after using the media. The test consisted of 10 context-based questions to evaluate students' understanding of integer operations. Before performing the t-test, normality (Kolmogorov-Smirnov) and homogeneity (Levene Test) tests were conducted.

**Table 3.** Normality and Homogeneity Test Results

| Test Statistic | Sig. Value | Description |
|---|---|---|
| Kolmogorov-Smirnov | 0.129 | Data normal |
| Levene Test | 0.174 | Homogeneous variance |

After meeting the normality and homogeneity assumptions, a paired sample t-test was conducted. The results indicated an increase in the average score from 56.3 in the pretest to 78.7 in the posttest. The t-test results are presented in Table 4.

**Table 4.** Pretest and Posttest t-Test Results

| Statistic | Value |
|---|---|
| Mean Pretest | 56.3 |
| Mean Posttest | 78.7 |
| t Value | 6.142 |
| Sig. (2-tailed) | 0.000 |

The significance value (0.000 < 0.05) indicates a significant improvement in learning outcomes after students used the media. These findings support previous studies that interactive media can significantly improve mathematical concept mastery through in-depth visualization and active student engagement (Astutik et al., 2021; Putri et al., 2023; Nugroho et al., 2020; Haryani et al., 2022; Suryani et al., 2024). The results of this study show that the developed

interactive web-based edutainment media (HTML5) is highly valid according to expert evaluations, very practical based on user perceptions (students and teachers), and effective in improving students' learning outcomes. These findings demonstrate that pedagogically designed game-based digital media can address the challenges of 21st-century mathematics learning through a contextual, engaging, and easily accessible approach.

***Discussion***

This study resulted in the development of an interactive learning media based on HTML5 in the form of an edutainment game specifically designed to enhance the understanding of middle school students regarding integer operations. This media was developed using the modified seven-stage Research and Development (R&D) model by Borg & Gall. The findings show that the developed media is highly valid in terms of content, design, interactivity, and technological aspects, is practical for use by both teachers and students, and is effective in improving student learning outcomes. These findings reinforce previous literature emphasizing the importance of technology-based innovations in the development of 21st-century mathematics learning media, particularly in the integration of cognitive content, affective approaches, and technological interaction (Permana et al., 2021; Wahyuni et al., 2020; Saputra & Rosnita, 2021; Nurjanah et al., 2023; Salim & Mustofa, 2022).

The high validity of the media was achieved through expert assessments of several critical dimensions, such as alignment with the curriculum, clarity of information delivery, graphic design quality, and technical execution of the program. These assessments indicated that the media meets pedagogical and technological standards for use in formal learning environments. Additionally, the practicality of the media was confirmed by feedback from both teachers and students, who rated the media as easy to use, requiring no installation, and functioning smoothly on various devices. This finding is consistent with research by Huda et al. (2021) and Yuliana et al. (2023), which assert that content validity and ease of access are key factors for the successful integration of technology in mathematics learning. Support from pretest and posttest results, which showed significant improvement, further emphasizes that this media is not only well-designed but also effective instructionally (Kusuma & Retnowati, 2022; Maulana et al., 2022; Prasetyo & Aini, 2021; Rahmawati & Sari, 2020; Nasruddin & Fauziah, 2021).

The HTML5 technology used in the development of this media provides significant advantages in terms of flexibility and portability. Unlike application-based media that require installation and tend to be resource-intensive on low-spec devices, HTML5-based media can be accessed directly through a browser on various platforms—laptops, tablets, or smartphones—without compromising visual quality or interactivity. This advantage makes the media highly relevant for educational settings still facing digital infrastructure challenges (Febriyanto et al., 2021; Widodo et al., 2023; Salsabila et al., 2024; Arifin & Setiawan, 2020; Fauzi et al., 2022). Moreover, the responsive game interface, use of point systems, rewards, time limits, and contextual problem presentation effectively created a competitive and enjoyable learning environment, an approach proven to enhance student focus and persistence across various studies (Zulnaidi & Zamri, 2021; Susanti & Faridah, 2020; Pratiwi & Widodo, 2018; Rahmawati & Sari, 2020; Kusuma & Retnowati, 2022).

The effectiveness of this media can also be analyzed through the lens of contemporary learning theories. Social constructivism theory, which emphasizes that knowledge is built through active experience and reflection, is highly relevant in the context of this media because students interact directly with the content, make decisions, and receive immediate feedback during gameplay. The simulation elements and challenges in the game create a dynamic learning environment and foster deeper cognitive engagement (Anderson & Krathwohl, 2001; Kusuma & Retnowati, 2022; Ningsih & Salamah, 2020; Nasruddin & Fauziah, 2021; Lestari et al., 2023). Additionally, the use of gamification principles such as scores, levels, and rewards in this media has been shown to enhance intrinsic motivation and extend students' engagement duration in learning activities. This aligns with research by Susanti & Faridah (2020) and Zulnaidi & Zamri

(2021), which suggests that gamification elements positively contribute to emotional engagement and sustained learning.

Emotional aspects cannot be overlooked in the successful implementation of this media. Previous studies have revealed that students' affective involvement, such as feeling happy, challenged, and proud after completing a mission in the game, correlates positively with learning outcomes. This game is designed with engaging visual elements and challenges, which have been shown to spark enthusiasm and focus in students' learning. In this context, the cognitive-affective theory in learning indicates that positive emotions during the learning process contribute directly to material absorption and information retention (Nasruddin & Fauziah, 2021; Salim & Mustofa, 2022; Lestari et al., 2023; Yuliana et al., 2023; Arifin & Setiawan, 2020).

Specifically, the topic of integer operations was chosen because it is a fundamental concept in mathematics that serves as the foundation for more advanced topics such as algebra, equations, and ratios. Misunderstanding of this concept often leads to systemic issues in student achievement at higher levels. In this context, the HTML5-based edutainment media developed proved effective in bridging conceptual difficulties through visual and interactive approaches that help students understand the rules of signs and order of operations in integers. This result supports the findings of Ningsih & Salamah (2020) and expands their study by integrating more comprehensive game design principles.

The implications of this research cover three important domains: pedagogical, technological, and policy. From a pedagogical perspective, teachers can utilize this media as an alternative strategy to package mathematics learning, which is often abstract and rigid, into a more contextual and enjoyable format. The media is easy to implement, as it requires no advanced technical skills. From a technological aspect, this development demonstrates that HTML5 is a promising platform for developing future learning media that is lightweight and cross-platform. From a policy perspective, the results provide empirical evidence that digital media can support the Merdeka Curriculum policy, which emphasizes student-centered, technology-based, and contextual learning (Maulana et al., 2022; Salsabila et al., 2024; Pratiwi & Widodo, 2018; Widodo et al., 2023; Salim & Mustofa, 2022).

## CONCLUSION

Penelitian ini menunjukkan bahwa pengembangan media pembelajaran interaktif berbasis HTML5 dalam bentuk game edutainment efektif dalam meningkatkan pemahaman siswa SMP terhadap operasi bilangan bulat. Media ini mendapatkan validitas tinggi dari segi isi, desain, interaktivitas, serta kepraktisannya dalam penggunaan di kelas. Hasil pretest dan posttest yang menunjukkan peningkatan hasil belajar siswa semakin memperkuat klaim bahwa media ini bukan hanya sah secara pedagogis, tetapi juga memiliki efektivitas dalam meningkatkan capaian belajar matematika. Selain itu, penggunaan HTML5 sebagai platform untuk pengembangan game memberikan keuntungan dalam hal portabilitas dan fleksibilitas, memungkinkan akses tanpa kendala perangkat keras tertentu, yang sangat relevan dengan kebutuhan pendidikan di berbagai konteks.

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