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Developing Interactive Game-Based Learning Media to Enhance Conceptual Understanding of the Human Digestive System in Elementary Education

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Abstract: This study aims to develop interactive game-based learning media on the human digestive system for elementary school students and to test the validity, practicality, and potential effectiveness of the media. The development model used is the Rowntree model, which consists of three main stages: planning, development, and evaluation. This model emphasizes systematic and structured media development to ensure effective learning. Formative evaluation is conducted using the Tessmer model, which includes one-to-one and small-group trials. The media's validity was assessed by media, content, and language experts, while its practicality was tested through one-to-one and small group evaluations. Potential effectiveness of the media was measured through field testing by comparing pre-test and post-test scores. The media's validity was assessed using percentage scores of 97.7%, 87.61%, and 94.81% from media, content, and language experts, with an overall average of 93.41%, which is categorized as very valid. The practicality aspect received a score of 88.55%, indicating it is highly practical. The field test results showed an average post-test score of 85.11 and an N-Gain of 0.72, both of which are considered high. Based on these results, it can be concluded that the interactive game-based learning media has high validity, practicality, and effectiveness. This media contributes explicitly to Science and Social Studies learning through an innovative gamification approach, distinguishing it from previous studies. The use of this media not only enhances students' understanding of the human digestive system but also introduces a fun and interactive learning method, providing a new learning experience for elementary school students. The novelty of this study lies in the gamification design developed to facilitate an understanding of abstract concepts related to the human digestive system, in accordance with cognitive learning theory. This design integrates visual and audio elements to support dual coding. Additionally, this media is also designed for offline use.

Keywords: development, learning media, interactive educational game, elementary school, human digestive system.

▪ INTRODUCTION

Education plays a central role in shaping an individual's quality and determining their future success. As society and technology evolve, the learning process must adapt accordingly. According to the National Education System, as regulated by Law Number 20 of 2003 (Ministry of National Education, 2003), education is defined as a conscious and planned effort to create a learning atmosphere and process that enables students to actively develop their full potential. In this context, the formal education system, supported by a well-structured curriculum, serves as the primary platform for achieving educational goals (Elice, Maseleno, & Pahrudin, 2024). At the elementary level, the curriculum lays the foundation for basic knowledge, particularly in science, which integrates physics, chemistry, and biology (Setiawan & Suwandi, 2022). To meet the demands of 21st-century skills, science learning must be designed with scientific and interactive approaches (Lafifa et al., 2023).

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One of the topics in elementary science with high complexity is the human digestive system. According to the Merdeka Curriculum for Grade V, this topic covers the digestive organs, including the mouth, esophagus, stomach, small intestine, large intestine, rectum, and anus. The digestive process involves complex interactions among various organs, as well as mechanical and chemical processes, and the roles of nutrients in the body (Sari & Bintang, 2022). This material requires a strong conceptual understanding and often poses challenges for students due to its abstract nature. Instructional media thus play a vital role in helping students bridge conceptual gaps. Well-designed media not only enhances understanding but also supports memory retention and increases cognitive engagement. Juhji and Nuangchalerm (2020) argue that science learning should be supported by media that develop scientific process skills such as observation, experimentation, and analysis, while also nurturing students' scientific attitudes.

Teachers are expected to select and use instructional media that align with students' characteristics. Visually appealing, contextually relevant media can simplify complex material in an engaging way. Ammar et al. (2024) emphasize that instructional media are integral to learning, helping students grasp difficult concepts and enabling teachers to deliver complex content effectively. Therefore, the development of instructional media that meets students' learning needs is essential to achieving educational objectives.

In recent years, interactive educational games have emerged as promising learning tools. These games go beyond entertainment, fostering student participation and motivation in learning (Ding & Yu, 2024). Through exploration, challenges, and feedback, educational games stimulate critical thinking and enhance understanding of learning materials (Katual et al., 2023). Game-based learning also encourages two-way interaction, making abstract science topics, such as the human digestive system, more accessible and engaging.

Despite the potential, the application of interactive media in elementary schools remains limited. Observations at a Grade 5 public elementary school in Pagarkaya Village reveal that teachers predominantly rely on lectures and printed materials. This conventional approach often leads to student disengagement, particularly when learning abstract concepts like the human digestive system. Initial observations and interviews with teachers revealed signs of student boredom and anxiety during the learning process, largely due to the use of traditional teaching methods. The use of lectures and less engaging learning materials makes it challenging for students to grasp complex topics, such as the digestive system. The lack of interactive media has also contributed to students' low motivation and learning difficulties. Teachers at this school report that current teaching methods and media have yet to facilitate meaningful learning experiences. Therefore, more engaging, visual, and interactive media are urgently needed to improve learning outcomes.

To address this gap, the present study proposes the development of an interactive educational game-based learning media using *Canva and Smart Apps Creator* (SAC). Unlike previous studies that often use web-based tools like Wordwall to create quizzes and simple interactive activities to increase student engagement, this research introduces more complex gamification features to foster student participation, strengthen conceptual understanding, and enable personalization. While Wordwall is effective in creating fun and engaging activities, it tends to be limited to static activities that cannot be adapted to individual learning needs. In contrast, the gamification features introduced in this study

include progressive levels, rewards, score-based challenges, and narrative elements tailored to students' abilities and interests. This innovation is designed to enhance elementary-level learning experiences that are adaptive, enjoyable, and effective.

Accordingly, this study aims to enhance the science learning outcomes of 5th-grade students regarding the human digestive system by utilizing interactive gamification-based learning media at a public elementary school in Pagarkaya Village, Sungai Keruh Sub-district. The study focuses on designing media aligned with the national curriculum and tailored to the characteristics of elementary students, while also examining its influence on conceptual understanding and learning motivation. The expected outcome is a valid, practical, and effective learning medium that improves the quality of science education at the elementary school level.

▪ METHOD

Participants

This study was conducted at one of the elementary schools (SD) in Musi Banyuasin Regency, South Sumatra, Indonesia. The population of this study consists of 60 fifth-grade students at SD Negeri 1 Pagarkaya for the even semester of the 2024/2025 academic year. The sample for this study was selected using random sampling, comprising 45 students and one teacher.

Research Design and Procedures

This study employed Rowntree's development model. The Rowntree model is well-suited to developing educational game media due to its structured approach and focus on clear, measurable learning objectives. This model also allows for adaptation to various student learning styles and the integration of continuous feedback, which helps enhance student understanding. Consists of three main stages: the planning stage, the development stage, and the evaluation stage. This model emphasizes a systematic process in designing, developing, and evaluating instructional media that is both effective and aligned with users' needs (Rowntree, 1994). In addition, this study also applied Tessmer's formative evaluation, which includes the stages of self-evaluation, expert review, one-to-one evaluation involves selecting six student to evaluate the interactive educational game that has been validated by expert lecturer and revised by the reseacher, small group evaluation the researcher will select nine students to use the interactive educational game that has been revised after one to one test, and field test. The purpose of this formative evaluation is to ensure the quality of instructional media through a series of progressive trials before broader implementation (Tessmer, 1998). This combined approach allows the development of instructional media that is not only systematically structured but also responsive to students' needs and characteristics.

Instrument

The interview guidelines, validation sheets, practicality sheets, and learning achievement test questions used for pretests and posttests are the research instruments employed in this study. The teachers were interviewed to identify students' needs. The data collection instruments in this study consist of achievement tests and questionnaires. The achievement tests, in the form of pretests and posttests, are used to measure students' conceptual understanding of the human digestive system material before and after using the developed teaching media. The test data analysis is conducted by comparing pretest

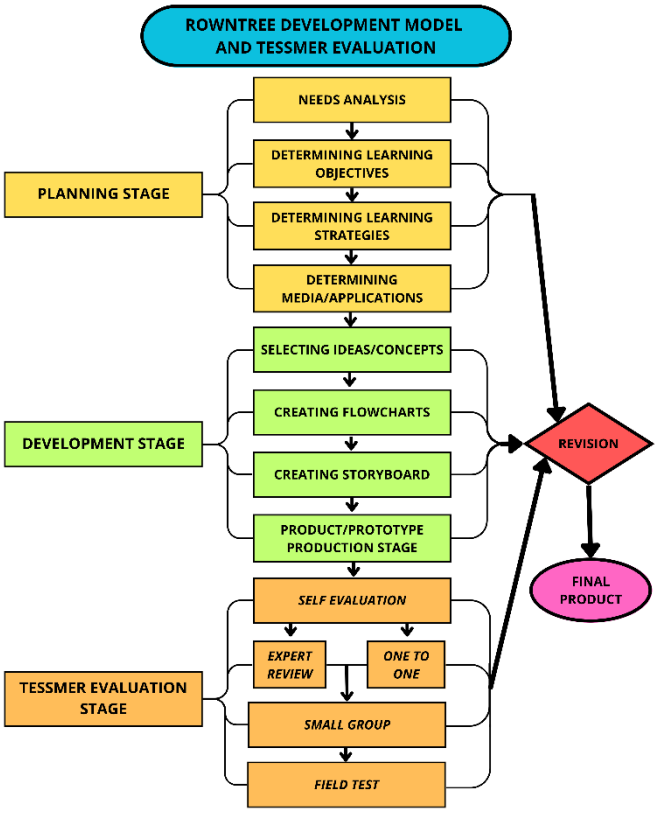

Figure 1. Rowntree development model and tessmer evaluation

and posttest scores and calculating the N-gain score to evaluate the potential effectiveness of the learning. The score categories in this study are based on the Minimum Mastery Criteria (MMC) used in elementary schools, with a score of 60 as the passing threshold. Therefore, scores below 60 are categorized as very poor, indicating that students have not achieved the expected level of understanding. This categorization prioritizes achieving MMC over achieving a score within the range.

Meanwhile, the questionnaire is used to collect data on the practicality and potential effectiveness of the teaching media. This questionnaire is administered to students in small groups to assess their responses to the use of teaching media. The instrument validation process is carried out through several stages. Content validation sheets are used to verify the content presented against the learning objectives. Media design validation sheets are used to assess the effectiveness and suitability of the developed media design for implementation in the learning process. Validation is conducted before the instruments are used in the study to ensure they accurately measure what is intended, including content, design, and the potential effectiveness of the teaching media.

Language validation sheets are designed to evaluate the appropriateness of the language used in teaching materials, ensuring it is clear and accessible to students, relevant to their level of comprehension, and consistent with applicable language standards. This validation aims to ensure that the material presented in the teaching media is not only effective in terms of content and design but also communicative and well-received by students in the learning context.

Data Analysis

During the planning stage, a needs analysis was conducted through observations, interviews, and questionnaires. The results revealed several challenges in science learning, particularly in the topic of the human digestive system. Students struggled to understand and recall the names and functions of the digestive organs. Instructional delivery was still dominated by lectures and conventional media, such as printed textbooks. Although YouTube videos were occasionally used, they lacked interactivity and did not support two-way communication. Meanwhile, school infrastructure, such as projectors, speakers, and internet connectivity, was available but underutilized.

Additionally, evaluations were conducted manually using printed worksheets, and no interactive applications were used. Teachers had not yet integrated platforms such as *Canva or Smart Apps Creator* (SAC) into their teaching, creating a significant opportunity to develop more engaging and accessible learning media. Student feedback also showed low levels of focus and active participation, especially during abstract lessons.

Based on the findings, interactive game-based media were designed in Canva and SAC to enhance student engagement and conceptual understanding in meaningful ways. The development stage began with defining the idea and concept for the media. Content focused on the human digestive system, supported by text, visual illustrations, audio narration, and embedded videos, all adapted for elementary learners and curriculum standards. Flowcharts were created to map the navigation and content structure. Storyboards were then developed to plan the visual layout, followed by the creation of a media prototype integrating animations, sound effects, and interactive quizzes. The media prototype was validated in the evaluation stage using Tessmer's formative approach. The expert review involved two validators in media design, two validators in content, and two validators in language. Data were collected using validation instruments and interviews. The validated media was revised based on expert feedback.

The one-to-one evaluation was conducted with six students to identify technical errors and initial user responses. Following this, a small-group evaluation with nine students assessed the practicality of the revised media in terms of usability and engagement. Finally, a field test was administered to a full class to evaluate the media's potential effectiveness. However, the absence of a control group in this study limits the ability to compare the results with those of a non-intervention group. The data collection instruments used in this study comprise learning achievement tests and questionnaires. A pretest was given prior to implementation, followed by a lesson using the developed media, and concluded with a posttest. The pretest and posttest results were analyzed to determine improvements in conceptual understanding and to calculate the N-gain score as a measure of potential effectiveness.

▪ RESULT AND DISSCUSSION

This section presents the results of developing interactive, game-based learning media on the human digestive system for elementary school students. The development followed the Rowntree model, which consists of three main stages: Planning, Development, and Evaluation. Evaluation was conducted using Tessmer's formative evaluation approach, comprising several trial stages. The following is a description of each stage:

Planning Stage

The research began with the planning stage, including a needs analysis to ensure that the developed instructional media aligned with the learning objectives and the characteristics of the learners. Student questionnaire results revealed that technical aspects were the most urgent need (80%), followed by aesthetic aspects (76%), cognitive aspects (75%), evaluation aspects (69%), and pedagogical aspects (65%). Students required media that were easy to use, engaging, helpful for understanding, and supportive of assessment.

Meanwhile, the teacher's needs analysis indicated that technical and evaluative aspects were equally dominant (44%), followed by pedagogical and cognitive aspects (38%), and aesthetic aspects (31%). Teachers preferred media that were easy to operate, supported assessment processes, and strengthened instructional strategies. These findings formed the basis for developing interactive, educational game-based media tailored to the needs of both students and teachers, particularly for the topic of the human digestive system in elementary science.

Learning objectives were defined based on the learning difficulties identified through student and teacher questionnaires. The targeted learning outcomes align with the national competency standards regarding students' understanding of the structure and function of human body organ systems. The Learning Objectives Flow (*Alur Tujuan Pembelajaran/ATP*) included the abilities to define, identify organs, explain their functions, sequence the digestive process, and understand the importance of digestive health. These objectives were specified into four targets: recognizing organs, explaining functions, sequencing processes, and understanding health maintenance.

The learning strategy was designed based on the characteristics of sixty Grade V students, who predominantly demonstrated an audiovisual learning style. The Discovery Learning model was selected, emphasizing exploration and conceptual discovery through direct experience, integrated with interactive educational games. The materials were presented in stages, beginning with animations and interactive narration, followed by tiered quizzes in the form of missions, which featured a point-and-badge system to foster motivation. The media design enabled students to learn through listening, viewing, and direct interaction with the content.

The learning media is developed as an interactive educational game for Android, as mobile devices are more accessible to students. The visual design of the media, including characters, backgrounds, icons, and a child-friendly interface, is created using Canva. At the same time, the interactive application is assembled using *Smart Apps Creator* (SAC) without coding, integrating elements such as animations, audio, video, quizzes, and a point system. This media is designed to be lightweight, easy to navigate, and compatible with a wide range of devices. The use of simple language, clear instructions, and engaging visuals makes this media effective in enhancing students' understanding and engagement.

Technology has great potential to enhance the learning experience, especially when the learning process is conducted through a blended method of face-to-face and online learning, which often faces challenges with traditional methods (Sareen & Mandal, 2024). This highlights the need for innovation in how learning materials are presented. Research by Byusa et al. (2022) demonstrates that educational games incorporating learning content can enhance students' abilities through enjoyable and interactive learning experiences. Additionally, students tend to prefer technology-based learning, such as

animations and videos, which can enhance their engagement and understanding of the material. This finding aligns with the research by Barakwan & Heriyawati (2024), which indicates that the use of educational game-based learning media, such as Quizalize, can increase student engagement and provide a more interactive and independent learning experience. Furthermore, teachers have expressed a need for technology-based teaching materials to support learning, particularly for complex topics such as the human digestive system, underscoring the importance integrating technology into the educational process.

Development Stage

This stage transformed the planning results into a tangible product: interactive, game-based learning media on the human digestive system. The development process began with the design of content, visual elements, and interactive features aligned with the results of the needs analysis. It involved creating graphics, writing narrative scripts, integrating audio, building the game structure in *Smart Apps Creator* (SAC), and designing engaging, relevant assessments. The development was based on the Rowntree model, supported by literature reviews and user feedback. The concept chosen was an Android-based educational game, given that elementary students have a preference for audiovisual learning and a strong interest in technology. The media design adopted a Discovery Learning approach within a game format, integrating text, illustrations, animations, videos, and interactive quizzes to promote student engagement and improve learning outcomes. A flowchart was constructed to ensure a logical structure and smooth navigation across the media. It illustrated the relationships among pages, user pathways, and the content-delivery sequence.

The production process marked the core implementation of the development phase, where all elements designed during the planning stage were realized into a functional product. Visual assets were created using Canva, including backgrounds, digestive organ icons, navigation buttons, and supporting illustrations. These visuals were adapted to the digestive system theme, taking into account aesthetic elements such as color harmony, clarity, and a child-friendly layout suitable for elementary students. The finalized designs were exported in high-resolution PNG format to maintain visual quality when used in the application. A new project was then initiated in *Smart Apps Creator*, with the screen size and orientation adjusted to match student device specifications. The PNG visuals were imported into the application and arranged across multiple learning screens following the predetermined flow. The layout was organized systematically to support learner comprehension and ease of use.

Interactive components such as navigation buttons, quizzes, and learning links were embedded to foster active student participation. Animations were added to create motion effects that brought the content to life, while audio elements served as narrations or sound effects to enhance clarity and maintain student attention. The final step in this process involved exporting the completed project as an APK (Android Package), enabling the application to run offline on Android devices. A functionality test was then conducted to ensure that all elements, including navigation, animations, audio, and assessments, functioned correctly and were free of technical errors. This testing was crucial for ensuring the usability and reliability of the media in real classroom environments. As a result, the final product was a fully functional, engaging, and child-friendly educational media application, tailored to the needs and characteristics of elementary school students.

The resulting interactive prototype serves as a complete representation of the media before validation by experts, providing a preview of the final structure and user experience. This prototype also serves a reference for revisions and further improvements based on expert feedback.

This development process follows the Rowntree Model, comprising planning, development, and evaluation stages, with expert input to ensure the product's quality and feasibility. This model has been proven effective in similar research, such as that by Ingtyas & Akmal (2024), which demonstrated significant improvements in student learning outcomes through the development of interactive multimedia using Macromedia Flash for science subjects in elementary schools.

Research by Alotaibi (2024) also demonstrates that educational games designed around learning content can enhance students' abilities through enjoyable and interactive learning experiences. Additionally, research by Wardoyo et al. (2021) suggests that incorporating educational game-based learning media into Construct 3 can enhance student engagement in learning and provide a more interactive and independent learning experience.

To conclude the development process, all elements (text, images, and videos) designed in Canva were compiled into an interactive prototype using Smart Apps Creator. This prototype served as a complete representation of the media prior to expert validation, providing a preview of its final structure and user experience. The prototype also served as a reference point for subsequent revisions improvements informed by expert feedback.

Evaluation Stage

The evaluation phase aimed to assess the validity, practicality, and potential effectiveness of the developed media. The evaluation process consisted of four stages: expert validation, one-to-one testing, small-group testing, and field testing. Expert validation and one-to-one testing were conducted to assess the design and content quality. Small group testing evaluated the media’s practicality in terms of usability and student responses. Finally, field testing measured the overall potential effectiveness of the media in actual learning environments.

Expert Review

In this phase, the interactive educational game-based media was assessed for validity through expert input on media design, content, and language. Expert validation and one-to-one testing determined the media’s validity, while small-group testing examined its practicality, particularly its usability and student engagement with the design and content. The field test aimed to assess the potential effectiveness of the media in improving students' learning outcomes through actual classroom implementation. Recapitulation of Expert Validation Results is presented in Table 1.

Table 1. Recapitulation of expert validation results

No	Validation Test	Score Obtained		Maximum Score	Percentage	Category
		Expert 1	Expert 2			
1.	Media Design Validation	94	98	100	97.77%	Very Valid

2.	Content/Material Validation	62	68	75	87.61%	Very Valid
3.	Language Validation	85	86	90	94.87%	Very Valid
	Average	80.33	84	88.33	93.41%	Very Valid

Table 1 presents the recapitulation of expert validation results for the interactive educational game-based learning media on the human digestive system. The validation involved three key aspects: media design, content/material, and language. The scores were obtained from two expert validators, and the results demonstrate high validity across all aspects.

The media design validation received the highest average score, with Expert 1 scoring 94 and Expert 2 scoring 98 out of a maximum of 100, resulting in a percentage of 97.77%. This suggests that the media design is well-structured, visually appealing, and functionally suitable for elementary school students.

This high score can be attributed to the application of multimedia design principles suitable for children. First, the media is designed to reduce cognitive load for children by presenting information in a structured and non-confusing manner. The use of visual elements such as images, animations, and videos helps children better understand the material being taught. Second, the simple and intuitive layout, along with easy navigation, allows children to use the application without confusion. Third, the media incorporates interactive elements, such as quizzes and engaging videos, which can enhance student engagement during the learning process.

These design principles have been proven effective in improving student learning outcomes. For example, research by Aldalur & Perez (2023) shows that educational games designed with an interactive approach can significantly improve student learning outcomes by creating enjoyable learning experiences and stimulating active engagement. Additionally, research by Silfia et al. (2024) highlights the importance of incorporating visual and interactive elements into learning media, which can help students better comprehend the material and enhance their motivation to learn.

Revisions were made based on expert feedback, including improvements to the wording of learning objectives, the addition of a video on digestive disorders in humans, and refinements to layout and language. Therefore, validating this media is crucial to ensure it is not only visually appealing but also able to effectively and enjoyably convey the material.

The content or material validation obtained scores of 62 and 68 from Experts 1 and 2, respectively, with a maximum possible score of 75. The resulting percentage was 87.61%, which still falls within the "Very Valid" category. These scores suggest that the learning material presented in the game is relevant, accurate, and supports the intended learning objectives. The language validation yielded scores of 85 and 86 from the two validators out of a maximum of 90, resulting in a percentage of 94.87%. This reflects that the language used in the media is appropriate, clear, and comprehensible for the target age group. Overall, the average percentage of all three validation aspects is 93.41%, which categorizes the product as “Very Valid.” These results confirm that the developed interactive educational game meets expert standards in design, content accuracy, and

language use, making it suitable for implementation in elementary school science learning.

One-to-one Testing Stage

After completing the validation stages for media design, content, and language, the next phase was the one-to-one testing. This stage aimed to identify weaknesses in the developed learning product based on students' perspectives, following expert evaluations. The one-to-one testing was conducted with 5th-grade students on Thursday, May 15, 2025. Six students were selected to participate in the one-to-one test: ZRA and FKA represented high-ability students; ARH and RHT represented medium-ability students; and DRY and SYA represented low-ability students. This one-to-one test was intended to gather feedback for improvement before proceeding to the practicality testing stage. Each student was asked to use the interactive educational game application and then provide suggestions and comments regarding the learning media. The students' feedback during the one-to-one testing stage is presented in Table 2.

Table 2. Student comments during one-to-one testing

No.	Student	Comment
1.	ZRA	The application is very enjoyable. The colors are suitable, and it includes sounds or music. I really like it.
2.	FKA	Learning becomes less boring because I can play while studying. I like it because the colors are bright and the sounds are funny.
3.	ARH	The media is very interesting, and the colors are appropriate. It has music and games too. It is really fun to use.
4.	RHT	I understand the lesson better because the explanations in the game are clear. I am happy because I feel smarter every time I level up.
5.	DRY	The game is fun and enjoyable. The application is colorful and attractive. There are cute cartoon images. I really like using this game.
6.	SYA	The challenges in the media are exciting and make me more enthusiastic about learning. The colors are cute, and there is an engaging learning video.

Based on the results of the one-to-one trial, students provided feedback on the learning media developed. The feedback received was minor, including adjustments to text layout and color selection, as well as refinements to several visual elements. The revision process following the one-to-one evaluation was completed in less than 24 hours, as the improvements focused solely on visual and presentation aspects without altering the media's main structure.

Small Group Testing Stage

The next stage was small-group testing of the revised product, based on feedback and suggestions from the previous six students. In the small-group testing, nine students participated, excluding the three who had participated in the one-to-one test. The primary purpose of this stage was to evaluate the practicality of the developed product. During this stage, students were also asked to complete a prepared student response questionnaire.

Table 3. Recapitulation of small group test results

Name	Total Score	Ideal Score	Practicality Percentage	Category
EYS	81	100	81%	Very Practical
FED	87	100	87%	Very Practical
JAL	90	100	90%	Very Practical
NAD	89	100	89%	Very Practical
RAP	92	100	92%	Very Practical
SYN	84	100	84%	Very Practical
MBI	92	100	92%	Very Practical
MAW	92	100	92%	Very Practical
NAS	90	100	90%	Very Practical
	Average		88.55%	Very Practical

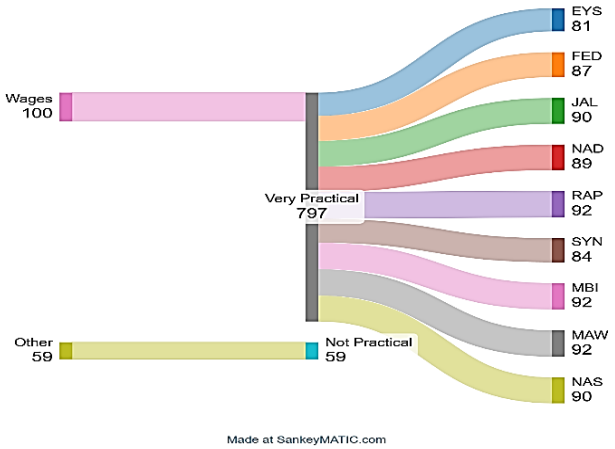

Figure 2. Recapitulation of small group test results

The results of the student response questionnaire distributed during small-group testing are presented in Table 3. Based on the recapitulated data from the small-group trial, the average practicality percentage was 88.55%. This result indicates that the developed product falls into the "very practical" category. This means the educational game can effectively meet students' learning needs in a practical manner and is easy to use in Science and Social Studies learning activities at the elementary school level. The detailed results of the practicality testing are presented in Table 4.

Table 4. Recapitulation of practicality test results

Aspect	Obtained Score	Ideal Score	Percentage Result (%)
Ease of Use	153	180	85%
Engagement & Motivation	158	180	87.77%
Material Comprehension	164	180	91.11%
Visual Design & Interactivity	162	180	90%
Suitability to Students' Needs	160	180	88.88%
Average	159.4	180	88.55%

Based on Table 4, the media's practical test results average 159.4 out of 180 (88.55%), indicating that the media are very practical. Each component evaluated showed a positive response, with ease of use at 85%, engagement and motivation at 87.77%, content understanding at 91.11%, visual design and interactivity at 90%, and alignment with student needs at 88.88%. The highest score was achieved in the content understanding aspect, indicating that this media is highly effective at delivering material to students. The clear design and use of visual elements that support understanding are the main factors behind this result.

However, some aspects, such as ease of use and student engagement, received slightly lower scores. This can be explained by some students experiencing minor difficulties at the beginning of using the application, particularly related to navigation and the lack of clear instructions in certain sections. Regarding visual design and interactivity, although it received a high rating, adjustments are needed to make it more responsive across the variety of devices students use. Overall, this media not only functions well but also successfully enhances student participation and understanding.

These findings align with the research by Li, Chen, & Deng (2024), which found that interactive game media can improve students' motivation and focus by creating an engaging learning environment. Therefore, further revisions on several aspects, such as simplifying navigation and adjusting content to match students' knowledge levels, will further increase the potential effectiveness of this media in supporting the learning process.

During the small-group trial, students responded positively to the features of the interactive educational game. They found the media engaging, easy to understand, and beneficial in improving their comprehension of the material. The presence of the interactive educational game added value, as it not only presents information visually but also encourages students to be more actively involved in the learning process. It should be noted that these results primarily come from the small-group evaluation, following initial feedback from the one-to-one evaluation. Based on the data collected, the researcher believes that this interactive educational game has great potential to become an innovative learning medium that supports Science and Social Studies learning in elementary schools, while also meeting the criteria of validity and practicality. Based on the data, the developed interactive educational game not only meets the criteria of validity and practicality but also has great potential to serve as an innovative learning medium that supports Science and Social Studies learning in elementary schools.

The four-day interval between the small-group test and the field test was considered sufficient to conduct further revisions, given that the media were developed independently by the researcher, who had mastered both the application and its development techniques. Therefore, the revised media was ready to be tested further in the field test stage.

Final Product

The final product has been validated by media design, subject matter, and language experts, as well as through limited trials, including one-to-one and small-group testing. Each of these stages was conducted to obtain input regarding the quality of content, appearance, potential effectiveness, and comprehensibility of the product. Based on the validation and trial results, the product has been revised and refined and is therefore

considered suitable for use as a learning medium. The final product of the Interactive Educational Game Learning Media is presented in Figure 3.

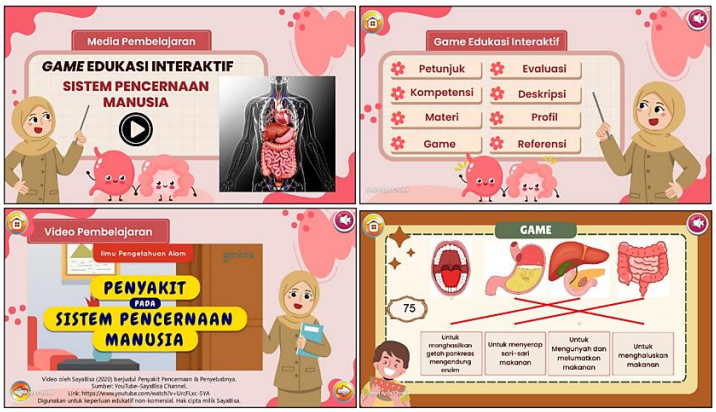

Figure 3. Final Product interactive educational game learning media

Field Test Stage

The field test was conducted on Tuesday, May 20, 2025, in Grade V at a public elementary school in Pagar Kaya village, involving a total of 45 students from two classes, and carried out over two class periods (2 × 35 minutes). It is essential to note that the 15 students who participated in the one-to-one and small group testing phase were excluded from the field test, which involved 45 students from two classes. This decision was made to avoid bias, as these 15 students had already been exposed to the media and content earlier. Before the field test, the researcher administered a pretest to measure students' prior knowledge of the material to be studied. For this pretest, the researcher created 20 multiple-choice questions on the Human Digestive System. The Minimum Mastery Criteria for Grade 5 in Science and Social Studies is 65. In the pretest phase, the researcher set a minimum threshold of 65 for learning achievement. The frequency distribution table of the N-Gain categories is presented in Table 5. The recapitulation of scores from the pretest and posttest activities completed by all students is presented in Table 6.

Table 5. Frequency distribution of n-gain categories

No.	N-Gain Category	Frequency	Percentage (%)
1.	Low	0	0%
2.	Medium	18	40%
3.	High	27	60%
	Total	45	100%

Table 6. Recapitulation of students' learning outcomes

Score Interval	Number of students		Percentage (%)		Description
	Pretest	*Posttest*	*Pretest*	*Posttest*	
90-100	0	22	0%	48.88%	Excellent
80-89	0	14	0%	31.11%	Good
70-79	0	9	0%	20%	Fair
60-69	10	0	22.22%	0%	Poor

0-59	35	0	77.77%	0%	Very Poor

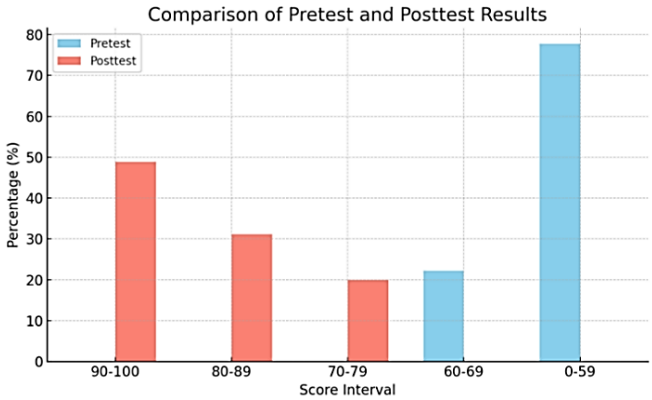

Figure 4. Diagram of students' pretest and posttest results

To observe the comparison of scores obtained by students from the pretest and posttest during the field test activity, refer to Figure 4. Based on the diagram in Figure 4, the comparison of students' pretest and posttest percentage results by score intervals is illustrated. The data show that before using the interactive educational game-based learning media, most students were in the 0–59 score interval, with the highest percentage at 78%, indicating a low initial understanding of the material on the human digestive system. However, after the learning session using the developed media, there was a significant improvement in the posttest results. Most students shifted to higher score intervals, with 47% scoring within the 90–100 range, 30% in the 80–89 range, and 20% in the 70–79 range. Meanwhile, no students remained in the 0–59 interval after the posttest.

These results indicate a clear difference in student learning outcomes in the Science and Social Studies, particularly in the Human Digestive System, before and after the implementation of interactive, game-based learning media. This demonstrates that utilizing interactive educational game-based media can indeed have a positive impact on students' learning achievement. The potential effectiveness of student learning outcomes was measured using the N-gain score, calculated from the average pretest and posttest scores. The recapitulation of the average pretest, posttest, and N-gain scores is presented in Table 7.

Table 7. Recapitulation of average pretest, posttest, and n-gain scores

Average Pretest	**Average Posttest**	**N-Gain**
44.66	85.11	0.72
Category		High

Based on Table 7, the N-Gain, calculated from the average pretest and posttest scores, was 0.72, which falls into the high category. This result indicates that the use of interactive educational game-based learning media was indeed effective in improving students' learning outcomes in the Science and Social Studies, specifically on the topic of the human digestive system.

Next, the data were analyzed using a Paired-Samples T-test to determine whether there was a significant effect in the study. The results of the Paired Sample T-test Hypothesis testing are presented in Table 8.

Table 8. Results of the paired sample t-test

		Mean	Std. Deviation	Std. Error Mean	Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pretest-Posttest	-40.444	12.784	1.906	-44.285	-36.604	-21.222	44	0.000

Based on the output of the Paired Sample T-Test, the value of t_count= 21.222 with t_table= 2.015 (df = 44) and a significance value of 0.000 < 0.05, which means Ho is rejected and Ha is accepted. This shows a significant difference in average scores between the pretest and posttest, demonstrating that the use of gamification in the human digestive system material for grade V elementary school students has a real effect on improving their learning outcomes. The results of this study indicate that the developed interactive game-based learning media are both valid and practical, demonstrating potential effectiveness in enhancing students' learning outcomes. This success can be explained by several key factors underlying the development and implementation of the media. The development process followed the Rowntree model, which emphasizes systematic planning, development, and evaluation to ensure high-quality content, design, and language. Validation by experts in media, content, and language further strengthens the legitimacy and quality of the media used in this study.

The potential effectiveness of this media can be explained using two main theories: Multimedia Learning and Dual Coding. Mayer states that combining visual and verbal elements in learning enhances students' cognitive understanding, as evidenced by the use of images and text in game-based learning media (Al-Khalidi, 2021). The Dual Coding theory is also relevant, as it emphasizes the importance of combining visual and verbal representations to strengthen the dual coding process in memory, thereby enhancing students' understanding of the material being taught (Dogomeo et al., 2022).

Moreover, the interactive elements, immediate feedback, and gamification within the media can motivate students to become more actively engaged in learning. This finding aligns with the research conducted by Hellin et al. (2023), which showed that gamification increases students' motivation and engagement in learning. The significant increase in pretest and posttest scores, with an N-Gain of 0.72 (in the high category), indicates that game-based learning enables students to engage in active learning through enjoyable experiences. This finding is also consistent with the meta-analysis conducted by Calzada et al. (2024), which concluded that educational games have a positive impact on learning outcomes and knowledge retention.

This study found that educational games can improve students' learning outcomes, a finding supported by Ren et al. (2024), who concluded that educational games have a positive impact on learning outcomes. Similarly, Putz et al. (2020) found that educational games have a positive influence on students' knowledge retention. However, there is a slight difference regarding ease of use compared to Zainuddin's (2023) study, which discusses the ease of use of educational game media. That study noted that the platform used affects the ease of use of the media. In our study, ease of use was more positive,

likely due to differences in the platforms used to develop the media. A simpler, more accessible platform for elementary school students provides a better experience with game-based learning media.

This finding is consistent with the research by Jaaska, et al. (2022), which showed that interactive game-based learning media can increase students' motivation and focus, as well as strengthened by the research by Zheng, et al. (2024), which found that Construct 3-based educational game media effectively enhances student engagement and understanding in learning. Sappaile's (2024) research demonstrated that gamified learning has a positive impact on the motivation of elementary students, potentially enhancing their academic achievement. Research by Sun et al. (2024) also found that students who learn using game-based media achieve better learning outcomes than the control class and become more motivated and active during the learning process. Additionally, research conducted by Smiderle et al. (2020) confirmed that the use of gamification elements has a positive impact on learning outcomes, student behavior, and motivation.

▪ CONCLUSION

Based on the research findings, it can be concluded that the interactive educational game-based learning media on the human digestive system for elementary school students is highly feasible. The validity of this media shows an average score of 93.41%, reflecting the quality of the design, the feasibility of the content, and the language use, all of which align with the students' characteristics. The practicality of the media is reflected in an 88.55% score from limited trials, indicating that it is easy to use and well-received by students. The media's potential effectiveness is evident from the significant improvement in learning outcomes: the average pretest score increased from 44.66 to 85.11 on the posttest, with an N-Gain of 0.72, which is classified as high. Thus, this media is not only valid and practical but also effective in improving students' understanding.

Limitations of this study include the fact that the trial was conducted at only one school and had a limited sample size, so generalization to other schools with different characteristics should be done with caution. Additionally, this study has not tested the long-term sustainability of using the media, so its potential effectiveness in repeated learning sessions remains untested.

The practical implications of this study are that teachers can utilize gamified media to enhance students' motivation, engagement, and understanding of the learning material, particularly in the context of the human digestive system. The use of this media allows students to become more actively engaged in the learning process through enjoyable and interactive experiences. Theoretical implications suggest that the use of gamification supports the constructivist theory, which emphasizes active student involvement in the construction of knowledge. This research also contributes to the development of technology-based learning theories applicable in the digital age.

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