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The use of android-based comic media in science learning to improve student learning outcomes

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ABSTRACT

Learning outcomes are key indicators of success in the learning process. This study focuses on the digestive system material and aims to analyze the feasibility and effectiveness of Android-based comic media in improving specific student learning outcomes, namely conceptual understanding and creative thinking skills. The media development followed the 4-D model, which includes four stages: Define (identifying learning needs and objectives), Design (planning the media content and interface), Develop (creating and validating the media with experts), and Disseminate (testing the media's effectiveness in the classroom). Validation by material and media experts showed very good validity scores of 87% and 85.25%, respectively. Effectiveness testing on 30 students at Taman Dewasa Junior High School in Jetis Yogyakarta demonstrated a significant improvement in students' creative thinking skills with an n-gain score of 69%. Compared to conventional learning media, the Android-based comic media offers interactive and visually engaging content that helps students better visualize and understand the digestive system material, creating a more motivating and enjoyable learning environment. However, this study is limited by its relatively small sample size and potential biases in measurement, which should be considered when generalizing the results. Overall, the use of Android-based digital comic media presents an innovative and effective solution to enhance science learning quality.

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Introduction

As a developing country, Indonesia continues to strive to improve the quality of human resources through education. Science education plays a crucial role in developing students' critical, creative, and logical thinking skills, which are essential for facing the rapid advancement of science and technology (Suyono, S., & Hariyanto, 2015). However, science learning outcomes in Indonesia, particularly on the topic of the digestive system, still show unsatisfactory results. According to the Global Talent Competitiveness Index (GTCI) 2020, Indonesia ranks 65th out of 135 countries in the Vocational and

Technical Skill (VT Skill) category and 84th in the Global Knowledge Skill (GK Skill) category (gtcistudy.com). This data indicates that Indonesia s human resource competitiveness remains low, partly influenced by suboptimal learning outcomes in schools.

This low learning outcome is also reflected in the average science exam score at the research site school, which is 60.3 (on a scale of 0-100), below the passing standard of 75. One of the factors affecting learning outcomes is the learning media used during the teaching process (Suryani, 2018). Effective learning media can enhance students motivation and understanding. In traditional learning environments, textbooks are often the primary resources used to convey subject matter. However, this conventional approach has been shown to have limitations in keeping students engaged and interested in learning. According to (Musfiqon, 2012), the use of monotonous learning media can reduce students' interest because it does not provide enough stimuli to spark curiosity or encourage active involvement in the learning process. Therefore, innovative and varied learning media are essential for creating an engaging and enjoyable learning atmosphere (Suryani, 2018).

In addressing this gap, the development of interactive learning media, such as Android-based comic media, offers a promising solution. This media format transforms complex scientific concepts, such as those related to the digestive system, into accessible and engaging content. Comics have been recognized for their potential to communicate abstract ideas in a clear, coherent, and enjoyable way, making learning both more effective and enjoyable (Yulianti, E., Purwanto, A., & Sumarni, 2016). Furthermore, the integration of animation, quizzes, and interactive components in digital comic media allows students to engage actively with the material and receive immediate feedback, thus enhancing their understanding (Lau, W. W. F., 2013).

Students at Taman Dewasa Junior High School in Jetis Yogyakarta, the site of this study, found the digestive system topic to be particularly difficult to understand. They expressed that the abstract nature of the material presented in textbooks made it hard to comprehend and remember. When asked, students stated that the use of visualization and animation would significantly aid their understanding of the complex process of digestion. This aligns with the findings of (Yulianti, E., Purwanto, A., & Sumarni, 2016), who argued that comics can be highly effective teaching tools in science education due to their ability to simplify and clarify difficult concepts.

Additionally, students reported that they felt more motivated and interested in learning when using technology-based media, such as smartphone applications. This is consistent with the views of Lau et al. (2013), who suggested that technology can help create a more enjoyable and engaging learning environment, which in turn can increase learning effectiveness. The use of Android-based digital comic media can address the need for more innovative and interactive learning tools in Indonesian schools. Not only does it provide a platform for students to better understand complex scientific topics, but it also helps make the learning process more enjoyable and accessible. Therefore, the development of such media is expected to have a positive impact on students' learning outcomes, especially in challenging subjects like the digestive system.

In today s digital era, the integration of technology in learning is vital to create an engaging and effective learning environment (Lau, W. W. F., 2013). One innovative learning media is the use of Android-based digital comics. Comics, traditionally known as entertainment media, are now being utilized as educational tools due to their ability to convey information clearly, coherently, and enjoyably (Yulianti, E., Purwanto, A., & Sumarni, 2016). This study develops an Android-based digital comic media focused on the digestive system topic with the aim of improving students science learning outcomes. This media is expected to help students visualize the material more easily and increase emotional engagement, which positively impacts character and learning motivation (Musfiqon, 2012).

The uniqueness of this research lies in the use of the 4-D development model by Thiagarajan (Trianto, 2015), which consists of four stages: define, design, develop, and disseminate. This model was chosen because it provides a systematic framework for developing valid and widely applicable learning media. The define stage includes needs analysis and preliminary studies, design involves media and prototype design, develop covers product validation and revision, and disseminate is the implementation and distribution phase. Previous studies have demonstrated the effectiveness of comic media in enhancing motivation and learning outcomes (Widyawati, W., & Prodjosantoso, 2015), but

this study adds innovation by integrating Android technology and the 4-D development model, which has not been widely applied to the digestive system topic.

Therefore, this study aims to develop and test the effectiveness of Android-based digital comic media on the digestive system topic to improve students science learning outcomes. The results are expected to provide practical contributions for educators in enhancing the quality of science learning through innovative technology-based media.

Method

This research employed the Research and Development (R&D) method using the 4-D development model introduced by Thiagarajan, which consists of four main stages: Define, Design, Develop, and Disseminate. This model was selected because it provides a systematic and structured framework for developing and testing innovative learning media products.

Define Stage

The Define stage aimed to identify the needs and problems to be addressed by this research. Initial analysis was conducted through direct classroom observations, interviews with science teachers and students, and a review of relevant literature. The findings revealed that the existing learning media were conventional and less engaging, resulting in low student learning outcomes. Based on this, the decision was made to develop Android-based comic media focused on the digestive system material as an innovative solution to enhance student engagement and learning effectiveness.

Design Stage

In the Design stage, the digital comic media product was conceptualized and planned in detail. This involved: (1) Defining clear learning objectives aligned with core competencies and basic competencies stipulated in the curriculum; (2) Creating storyboards and initial prototypes, including character sketches, storyline development, and dialog writing tailored to the digestive system topic; (3) Designing the comic media to be visually appealing and linguistically accessible to junior high school students; (4) Utilizing digital design and development software such as Corel Draw X5 for graphic design, Sparkol Videoscribe for animation, and Articulate Storyline 2 for interactivity, ensuring the product is user-friendly and engaging.

Develop Stage

The Develop stage encompassed the creation of the initial product, expert validation, revision, and field trials: (1) Expert Validation: The initial comic media was evaluated by two groups of experts: material experts specializing in science education and media experts with experience in educational technology. Validation instruments included structured questionnaires assessing content accuracy, presentation quality, language clarity, and visual design. The questionnaires used a Likert scale (1 5) to measure feasibility and attractiveness. The experts profiles included university lecturers in science education and instructional design professionals; (2) Revision: Feedback from experts was systematically analyzed, and necessary revisions were made to improve content accuracy, visual appeal, and usability; (3) Field Trial: The revised comic media was tested on a randomly selected class of 32 students from the four available classes (VIII 1, VIII 2, VIII 3, VIII 4) at Taman Dewasa Junior High School Jetis Yogyakarta. The limited sample size was due to constraints in time and resources. Ideally, trials would be conducted across multiple classes or schools to enhance external validity; (4) Data Collection Instruments: Student responses to the comic media were collected through questionnaires measuring engagement and satisfaction. Learning outcomes were assessed using pre-test and post-test instruments designed to measure knowledge of the digestive system. These tests were validated for content and reliability through pilot testing and expert review.

Disseminate Stage

The Disseminate stage involved the distribution and implementation of the validated comic media: (1) The media was introduced to science teachers through workshops and training sessions to facilitate adoption; (2) The comic media was made accessible via digital platforms such as the Google Play Store, enabling wider student access; (3) Follow-up evaluations were planned to monitor usage and gather feedback for continuous improvement.

Data Management and Analysis

There are: (1) Data Processing: Pre-test and post-test scores were tabulated and analyzed to measure learning improvement; (2) Statistical Analysis: The normalized gain (N-gain) was calculated to quantify the effectiveness of the comic media in improving student learning outcomes. Additionally, paired sample t-tests were conducted to determine the statistical significance of the observed improvements; (3) Validity and Reliability: Instruments were tested for validity through expert review and for reliability using Cronbach s alpha, ensuring consistent and accurate measurement.

Technical Details

First, the comic media was developed using Corel Draw X5 for graphic design, Sparkol Videoscribe for animation effects, and Articulate Storyline 2 for interactive features. Second, the application was designed to be compatible with Android devices meeting minimum specifications: Android OS version 6.0 or higher, 1GB RAM, and 100MB free storage. Third, distribution was planned through the Google Play Store to ensure easy access and updates.

Experimental Design

There are: (1) The study employed a pre-test and post-test control group design; (2) One class was randomly selected as the experimental group to receive the comic media intervention; (3) A control group was maintained using conventional learning media; (4) Randomization was limited due to logistical constraints, which is acknowledged as a limitation.

Limitations

First, the sample size was limited to one class due to time and resource constraints, which may affect the generalizability of the results. Second, technical challenges during media development, such as software compatibility and device limitations, were encountered and addressed. Third, the study duration limited the extent of dissemination and follow-up evaluation.

Instruments and Data Analysis

The instruments used in this study include expert validation questionnaires, student response questionnaires, and learning outcomes tests. The expert validation questionnaire was used to assess the feasibility and quality of comic media based on the views of experts. The student response questionnaire was used to measure students' responses and level of satisfaction with the comic media used. The learning outcomes test was used to measure the increase in students' knowledge and understanding before and after using comic media. The data collected were analyzed quantitatively and qualitatively. Quantitative analysis was carried out by calculating the percentage, average, and n-gain score to see the improvement of student learning outcomes. Qualitative analysis was carried out by analyzing responses and suggestions from experts and students to improve and further develop comic media. By using the R&D method and the 4-D development model, this research is expected to produce learning media that is innovative, interesting, and effective in improving student learning outcomes on digestive system material.

Results and Discussions

The creation of Android-based comic media focused on digestive system content has yielded promising outcomes in enhancing students' academic performance. The average normalized gain (N-gain) of 69% indicates a notable improvement in students' comprehension after using the media, which reflects the media s effectiveness in supporting meaningful learning experiences. Compared to earlier studies, such as Yulianti et al. (2016), which reported N-gain values of 50% to 60% using traditional multimedia tools, this research shows a higher level of improvement. This suggests that the comic-based format offers enhanced engagement and comprehension, particularly for complex biological topics such as the digestive system. The significant increase in student performance can be attributed to the engaging, visual, and interactive nature of the media. The comic format transforms abstract and intricate concepts of the digestive system into accessible, captivating narratives complemented by vivid illustrations. This approach aligns with (Mayer, 2009) Cognitive Theory of Multimedia Learning, which asserts that combining verbal and visual elements improves understanding and memory retention.

Presenting the content in a narrative format helps students form stronger connections with the material and internalize the concepts more effectively. Research by (Taufik, A. N., & Rahman, 2017)

also supports the idea that narrative-based learning materials, like comics, significantly enhance student engagement compared to static text or images alone. However, the current study extends this approach by incorporating interactive features available on the Android platform, a factor not previously explored in earlier research. These interactive elements further enrich the learning experience, making the comic media not only engaging but also educational. A crucial aspect of this media's success is the emotional engagement fostered through the inclusion of compelling storylines and relatable characters. Tatalovic, (2009) emphasized that emotional involvement in educational content increases attention and interest, which are critical factors for effective learning. This emotional connection is likely responsible for the observed rise in student motivation and enthusiasm, as reflected in survey responses from participants.

Previous studies, such as those by Wulandari, S. W. M., et al. (2021) also highlight the importance of emotional engagement in science education, though their focus was primarily on video-based media. In contrast, this study introduces the comic medium, which combines emotional appeal with interactivity, offering the potential for sustained motivational effects. The unique combination of storytelling and digital interactivity may be more effective at maintaining student interest over extended periods.

The use of the Android platform has proven beneficial in providing students with easy, anytime access to the learning media, which facilitates self-paced learning. Interactive features, such as animations, quizzes, and clickable elements, offer immediate feedback, which has been shown to improve learning outcomes (Lau, W. W. F., 2013). This integration of technology fosters active learning by allowing students to revisit challenging concepts and study at their own pace, which is especially advantageous for mastering complex subjects like the digestive system (Yulianti, E., Purwanto, A., & Sumarni, 2016).

While previous research, such as Taufik, A. N., and Rahman, (2017), has explored mobile learning applications, these studies often lacked the comic-based narrative structure featured in this study. The combination of technology and storytelling is a novel approach that takes digital learning tools to the next level, offering a more interactive and engaging learning experience. This advancement in educational media design provides a valuable contribution to the growing body of literature on mobile learning and multimedia education.

In terms of context, the preliminary study conducted at Taman Dewasa Junior High School in Jetis, Yogyakarta, identified significant gaps in the science learning process. Direct observations and interviews with teachers and students revealed that the predominant use of textbooks as the sole learning resource led to student disengagement, boredom, and a lack of interest in the subject matter. (Musfiqon, 2012) argued that monotonous learning materials fail to stimulate curiosity or active involvement, leading to reduced student interest in the learning process. Similarly, (Suryani, 2018) highlighted the importance of diverse and innovative learning media in creating a more enjoyable and engaging educational environment.

Interviews with science teachers further confirmed the challenge of developing creative and innovative learning materials. Many teachers still rely heavily on traditional lecture methods and textbooks, as they lack the time and technical skills to incorporate technology into their teaching practices. This aligns with the findings of (Beemt, A. V., 2016), who noted that many teachers struggle with the integration of technology into their classrooms, often due to a lack of familiarity or expertise.

Students, on the other hand, reported that they found the digestive system material particularly difficult to understand and remember, especially the abstract concepts presented in traditional textbooks. However, students indicated that the use of visual aids and animations would significantly enhance their ability to comprehend the complex process of digestion. This sentiment aligns with (Yulianti, E., Purwanto, A., & Sumarni, 2016), who emphasized that comics have great potential to effectively communicate complex scientific concepts in an engaging and easy-to-understand manner.

In addition, students expressed a strong preference for using technology-based media, such as smartphone applications, as part of their learning process. As (Lau, W. W. F., 2013) highlighted, technology can help create a more engaging and enjoyable learning environment, which in turn enhances learning effectiveness. The integration of Android-based digital comic media addresses these

needs by offering a more dynamic, interactive, and accessible format for presenting educational content.

The advantages of using comics in science education are numerous. First, comics have the ability to visualize abstract concepts, making them easier to understand and remember. Second, the narrative structure and characters in comics can increase emotional engagement, further boosting student interest and motivation. Finally, comics provide an enjoyable alternative to traditional learning materials, helping students better connect with and retain the content (Tatalovic, 2009a).

Previous studies have also confirmed the effectiveness of comic media in improving student learning outcomes. (Widyawati et al., 2019) found that comic-based learning materials significantly enhanced students' motivation and academic performance. Similarly, (Purwanto, 2013) reported that the use of comics in mathematics education improved student achievement and engagement. These findings support the idea that comics can be a powerful tool for improving student learning outcomes across various subjects. Based on the results of this preliminary study, it is clear that there is a need for innovative, technology-based learning media to improve student performance in science education. The development of Android-based digital comic media focused on digestive system material offers a promising solution to address the challenges faced by both students and teachers at Taman Dewasa Junior High School. This comic media not only helps students better understand the material but also makes the learning process more engaging, enjoyable, and interactive.

The findings from this study underscore the importance of integrating innovative educational technologies into the learning process. By leveraging tools like Android-based comics, educators can provide students with a more dynamic and effective learning experience, which ultimately leads to better academic outcomes. This research contributes to the growing body of knowledge on the benefits of multimedia learning, particularly in the context of science education.

Product Design Stage

The product design stage in developing Android-based comic media is carried out carefully and systematically to ensure that the final product can meet learning needs and improve student learning outcomes. This stage begins by referring to the results of preliminary studies and literature reviews that have been carried out previously. The digestive system material is studied in depth and integrated into an interesting and interactive digital comic.

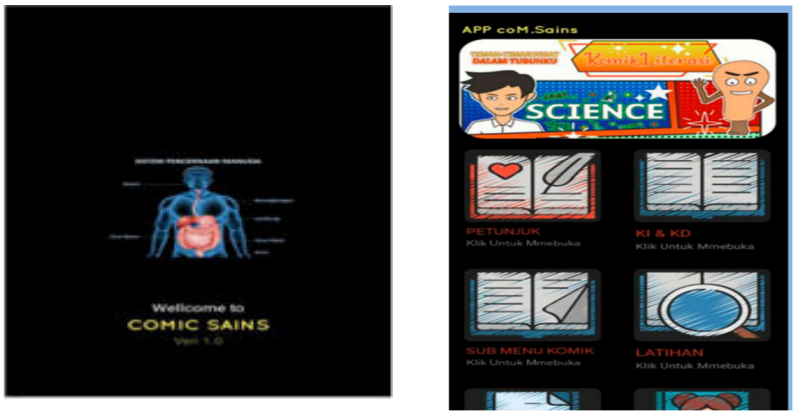

Figure 1 Opening Page View of the Product Description

Digestive System Material Thedigestive systemmaterial that will be presented in the comic media includes the definition, function, and process of food digestion in humans. Each component of the digestive system, starting from the mouth, esophagus, stomach, small intestine, large intestine, to the anus, is explained in detail. This explanation is complemented by visual illustrations that help students understand how food is processed and absorbed by the body. According to (Agustina, 2014) visualization of material helps students remember and understand abstract concepts more effectively.

Comic Media Component Specifications Comic media component specifications include character and character creation, storyline, illustrations, dialog, and evaluation questions: (1) Character and Character Creation: The characters in the comic are designed to appeal to students. The main character

is usually a student who is studying the digestive system, with assistance from a scientist or teacher who explains the material. The use of anthropomorphic characters such as "Mouth" who speaks and explains its role in the digestive system can make the story more vivid and interesting (Yulianti, E., Purwanto, A., & Sumarni, 2016); (2) Storyline: The storyline is organized by following the stages of the food digestion process. The story starts from the mouth, where food is chewed and mechanically digested, then proceeds to the esophagus, stomach, small intestine, large intestine, and ends at the anus. A coherent and logical storyline makes it easier for students to follow and understand the material presented (Widyawati, W., & Prodjosantoso, 2015); (3) Illustrations: Illustrations in comics play an important role in attracting attention and aiding student understanding. Each stage of digestion is depicted with clear and interesting illustrations. The use of bright colors and detailed images makes comics more interesting and easy to understand (Musfiqon, 2012) ; (4) Dialogue: Dialogue between characters in the comic is organized in simple and easy-to-understand language. Dialogue is used to explain important concepts in the digestive system and answer questions that may arise in the minds of students. The use of interactive dialog can increase student engagement in the learning process (Tatalovic, 2009a); (5) Evaluation Questions: Each end of the story in the comic is equipped with evaluation questions that aim to measure students' understanding of the material that has been learned. These questions are arranged in the form of multiple choice and short fillings that cover the entire digestive system material. This evaluation is important to ensure that students not only read the comics, but also understand and master the material presented (Suyono, S., & Hariyanto, 2015).

Initial Product Design includes storyboarding and flowcharting

Storyboard: Storyboards are used to plan and visualize each scene in a comic before the creation process begins. Storyboards help writers and illustrators to organize the storyline, determine character positions, and design dialogue. By using storyboards, the development team can ensure that each part of the comic is well presented and in accordance with the learning objectives (Trianto, 2015).

Flowchart: Flowcharts are used to describe the flow of information and interactions in the comic. Flowcharts help in designing the navigation and user interface, so that students can easily interact with the comic. Flowcharts are also used to identify evaluation and feedback paths in the comic, ensuring that students get an interactive and structured learning experience (Lau, W. W. F., 2013).

This product design stage is very important because it determines the quality and effectiveness of the comic media to be developed. With careful design and based on the results of preliminary studies and literature reviews, it is hoped that this Android-based comic media can improve student learning outcomes and make science learning more interesting and fun.

Product Development Stage

The product development stage is a critical phase in making Android-based comic media. At this stage, the design that has been designed previously is realized into a real product. Development is carried out in stages, starting from making initial products, validation by experts, limited trials, field trials, to evaluating the effectiveness of the media. The following is a recapitulation table of media expert validation results:

Table1. Recapitulation of Media Expert Validation Results

Aspects	Number of questions	Value (%)	Criteria
Feasibility of Shop Illustration in comics	5	85	Very good
Appropriateness of storyline presentation	5	82	Very good
Feasibility of Language Presentation	5	86	Very good
Feasibility Presentation format	5	88	Very good
Total Score	20	85,25	Very good

In the evaluation of Android-based digital comic learning media, the feasibility aspect of store illustrations scored 85%, categorized as good. The storyline and language presentation aspects each scored 82%, categorized as excellent. Meanwhile, the presentation format feasibility aspect scored 86%.

Overall, this media scored 88%, placing it in the excellent category and feasible to be tested and used in science learning.

Initial Product Creation Initial product creation was done using graphic design and animation software such as Corel Draw X5, Sparkol Videoscribe, and Articulate Storyline 2. This process involved illustration creation, storyline development, dialog writing, and integration of visual and textual components into a digital format. This initial product was designed to attract students' interest through attractive and interactive visualizations (Suyono, S., & Hariyanto, 2015).

Validation by Experts The initial product that has been completed is then validated by material experts and media experts. This validation aims to ensure that the content and appearance of comic media are in accordance with learning standards and are attractive to students. The validation process uses a Likert scale with the assessment categories very good, good, sufficient, not good, and very bad (Trianto, 2015). Material experts were tasked with assessing the feasibility of comic content, including the accuracy of scientific concepts, clarity of explanation, and relevance of the material to the curriculum. Media experts assessed the visual and interactive aspects of the comics, including the quality of illustrations, clarity of layout, and user navigation. The results of the validation that has been carried out by material experts, then recapitulate and analyze the results of the validation. The following is a recapitulation table of the results of the material expert validation;

Table 2. Recapitulation of Material Expert Validation Results

Aspects	Number of questions	Value (%)	Criteria
Quality of Content	5	85	Very good
Feasibility of Language Presentation on the material	5	88	Very good
Applicability of the material	10	88	Very good
Total Score	20	87	Very good

The validation results show that Android-based comic media has a feasibility value of 85.25% from media experts and 87% from material experts, both with very good categories. This value shows that comic media is feasible to use in science learning and has the potential to improve student learning outcomes.

Limited Trial After validation, a limited trial was conducted involving 10 8th grade students at Taman Dewasa Junior High School in Jetis Yogyakarta. This trial aims to get direct input from end users regarding the effectiveness and acceptability of comic media. Student assessment questionnaires were used to measure students' responses to comic media in terms of media and effectiveness. The results of the limited trial showed that Android-based digital comic media was rated very well by students, with a score of 83.43% and 82.00% respectively. These results indicate that students give a positive response to the comic media used in learning. The following data recapitulates the results of the Student Assessment Questionnaire in the Limited Trial in table 3.

Table 3. Recapitulation of Student Assessment Questionnaire Results on Limited Trial

Aspects	Number of students	Value (%)	Criteria
Media	10	83.43	Very good
Effectiveness Media	10	82,00	Very good
Total	10	82,71	Very good

Field Trial The field trial was conducted involving 30 students of class VIII B. The research design used was a pretest-posttest control group, where the experimental group was treated using Android-based comic media, while the control group was not. The purpose of the field trial was to test the effectiveness of comic media in improving student learning outcomes.

Before the treatment, both groups were given a pretest to measure their initial knowledge of the digestive system. After that, the experimental group learned using digital comic media, while the control group learned with conventional methods. After the learning period, both groups were given a

posttest to measure the improvement of their learning outcomes. The t-test results show that there is a significant difference between student learning outcomes before and after using digital comic media, with a significance value of 0.000 <0.05. This shows that the use of Android-based digital comic media is effective in improving student learning outcomes compared to conventional learning methods. Media Effectiveness Test The effectiveness of the media was tested using N-gain to determine the increase in student learning outcomes. N-gain is a measure used to determine how much improvement in learning outcomes after treatment. The results of the N-gain analysis showed a value of 69%, which is categorized as moderate in improving student learning outcomes. This value shows that Android-based digital comic media is quite effective in improving students' understanding of digestive system material (Hake, 1999).

Positive Outcomes and Potential Limitations of Android-Based Comic Media

The development of Android-based comic media on digestive system material has shown positive results in enhancing students' learning outcomes. Expert validation indicated that the media had excellent quality in both content and presentation, with a material feasibility score of 87% and a media feasibility score of 85.25%. Positive feedback from students during the limited trials also demonstrated that this media could attract interest and boost their motivation to learn.

"This digital comic media provides an interactive and enjoyable learning experience, motivating students to better understand the digestive system material" (Source: Expert Validation, 2025). However, the limitation regarding technological access aligns with Rahman's (2020) findings, which highlight infrastructure challenges as a major barrier to implementing digital learning media in schools in developing regions. Additionally, (Mayer, 2009) emphasizes the critical role of teachers in guiding students to focus not only on visuals but also on deeply understanding the concepts.

Qualitative Data from Student Feedback

In addition to quantitative data, qualitative feedback from students provided valuable insights. Some students expressed that the comic media made previously difficult material easier to understand due to its engaging presentation and clear narrative. "I find it easier to understand the digestive system because the pictures are interesting and the story is clear," said one student (Interview Results, 2025). However, some students also mentioned the need for additional explanations from teachers to grasp abstract concepts within the digestive system material. "Sometimes I still get confused with some concepts, so I need explanations from the teacher," said another student (Interview Results, 2025). This supports the view of Bransford, Brown, and Cocking (2000), who argue that digital learning media should be complemented by teacher interaction to optimize student understanding.

Impact of the Media on Creative Thinking and Understanding of Abstract Concepts

The N-gain analysis showed a 69% improvement in students' creative thinking skills, categorized as moderate. The Android-based digital comic media helped students develop creativity through visualization and storytelling that stimulated imagination and critical thinking. "The use of this digital comic media facilitates the development of students' creativity in a fun and interactive way" (Data Analysis Source, 2025). This media also aids in understanding abstract concepts by transforming complex material into more concrete images and stories that are easier to internalize. However, active interaction with teachers remains necessary for clarification and deeper comprehension. According to (Novak, 1998), visual media such as comics can assist students in constructing concepts through concrete visual representations, making it easier to internalize abstract material. Nonetheless, teacher interaction is crucial to ensure deep understanding.

Practical Implications for Teachers and Schools

This study offers several practical recommendations for teachers and schools in implementing Android-based comic media: (1) Teacher Training: Teachers need training to optimize the use of this media, including integrating it with effective teaching methods so that students do not focus solely on visuals but also deeply understand the concepts. (Darling-Hammond, L., Hyler, M. E., & Gardner, 2017); (2) Ongoing Media Development: Schools and media developers should continuously develop content tailored to students needs and local characteristics, ensuring broad accessibility. (Kozma, 2003); (3) Use as a Supplement: Comic media should be used as a supplement to conventional teaching methods, providing students with a balanced learning experience between visualization and conceptual discussion (Clark, R. C., & Mayer, 2023); (4) Adaptation for Various Schools: Schools with

limited technology can adopt printed versions or use the media during computer lab or library sessions where facilities are available (UNESCO, 2019).

Advantages of Digital Comic Media

The use of digital comic media offers several significant advantages in creating a more engaging and interactive learning environment. According to (Tatalovic, 2009b), comics are a popular art form that can be utilized in education and communication. Comics are not only entertaining but can also convey information and scientific concepts in a more interesting and understandable way. Android-based digital comics also provide easy access and use without printing costs, making them practical for both students and teachers. Comics as learning media allow the delivery of material in a more visual and narrative way. The images and stories in comics can help students visualize abstract concepts, making them more concrete and memorable. Furthermore, the storyline in comics can make students more emotionally and cognitively engaged in the learning process.

Positive Contribution to Learning

The use of innovative, technology-based learning media such as digital comics can make a positive contribution to improving student learning outcomes. Technology enables the delivery of material in a more interactive and engaging manner, making the learning process more dynamic and enjoyable. According to (Lau, W. W. F., 2013) technology in education can help increase student engagement, facilitate independent learning, and provide a wider range of learning resources. Android-based digital comics also provide flexibility for students to learn anytime and anywhere. They can access learning materials through mobile devices, making it easier for them to review lessons and deepen their understanding. This is in line with the findings of (Beemt, A. V., 2016), who pointed out that the use of technology in education can increase learning effectiveness and better align with modern students' learning styles.

Recommendations for Development and Implementation

Based on the results of this study, it is recommended to continue developing and implementing interesting and interactive learning media in the classroom. Teachers and educators should be more open to using technology in learning and continue to find innovative ways to enhance student learning outcomes. The development of technology-based learning media, such as digital comics, should be carried out on an ongoing basis, taking into account students' needs and characteristics. Additionally, teacher training on the use and development of technology-based learning media is crucial. Teachers should be equipped with sufficient skills and knowledge to utilize technology in the classroom, enabling them to create a more effective and engaging learning environment for students. Therefore, it is expected that the use of technology in education can contribute significantly to improving the quality of education in Indonesia.

Conclusions

Digital comic-based learning media using Android has been proven to effectively improve student learning outcomes. This research shows that the application of technology in learning media can create an interesting and fun learning environment, which increases student engagement and motivation during the learning process. The results of this study also show a significant increase in student learning outcomes using digital comic media compared to conventional methods.

Comics as learning media offer various advantages, including their ability to convey material visually and narratively. This is very helpful for students in understanding abstract and complex concepts, such as the digestive system. In addition, interaction through digital comics allows students to learn independently and repeat the material, thus deepening their understanding of the material taught.

Validation by experts and positive responses from students confirm that this comic media is very feasible to use in learning. With an excellent level of feasibility from material and media experts, as well as N-gain scores showing improvement in students' creative thinking skills, this digital comic media is considered an effective and innovative learning tool.

To continuously improve the quality of education in Indonesia, there is a need for continuous development on innovative and technology-based learning media. It is important for teachers and educators to be trained in using learning technology in order to utilize the potential of this technology to create a more effective and engaging learning environment. This will hopefully contribute significantly to improving the quality of learning and student learning outcomes in Indonesia.

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