INTERACTIVE VIDEO-BASED LEARNING MODULE DESIGN FOR DIGESTIVE SYSTEM MATERIAL AT SMPN 2 CIMAHI, CIMAHI CITY, WEST JAVA PROVINCE

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Abstract:*This study aims to design and develop an interactive video-based learning module for the digestive system material taught in Grade VIII at SMPN 2 Cimahi, West Java Province. The research is motivated by the limited effectiveness of conventional teaching methods and the low level of student engagement in grasping abstract biological concepts. Employing a Research and Development (R&D) approach, the study adopts the ADDIE model—Analysis, Design, Development, Implementation, and Evaluation. The needs analysis revealed that the majority of students struggled with understanding digestive processes and strongly preferred visual-interactive media. The design and development phases produced a comprehensive module integrating 3D animations, virtual simulations, interactive quizzes, and augmented reality features to foster meaningful learning. Limited trials demonstrated significant improvement in students' learning outcomes, with an average normalized gain score of 0.64 and high engagement levels. Expert and practitioner validation indicated an excellent degree of feasibility across academic, technical, and practical dimensions. The resulting educational module proves to be an effective and innovative tool, well-aligned with the cognitive characteristics of junior high school students and the pedagogical demands of the digital age.*

Keywords: interactive video, digestive system, learning module

Abstract: ***:*** *Penelitian ini bertujuan untuk merancang dan mengembangkan modul pembelajaran berbasis video interaktif pada materi sistem pencernaan untuk siswa kelas VIII di SMPN 2 Cimahi, Provinsi Jawa Barat. Latar belakang penelitian ini didasari oleh rendahnya efektivitas pembelajaran konvensional dan rendahnya partisipasi aktif siswa dalam memahami konsep-konsep abstrak pada materi sistem pencernaan. Metode penelitian yang digunakan adalah Research and Development (R&D) dengan model pengembangan ADDIE (Analysis, Design, Development, Implementation, dan Evaluation). Hasil tahap analisis menunjukkan bahwa mayoritas siswa mengalami kesulitan memahami materi sistem pencernaan, serta memiliki preferensi tinggi terhadap media visual-interaktif. Tahap desain dan pengembangan menghasilkan modul dengan integrasi animasi 3D, simulasi virtual, kuis interaktif, dan fitur augmented reality yang mendukung pembelajaran aktif. Uji coba terbatas menunjukkan peningkatan signifikan pada hasil belajar siswa dengan gain score rata-rata 0,64 serta tingkat keterlibatan yang tinggi. Validasi ahli dan praktisi menunjukkan tingkat kelayakan modul yang sangat tinggi dari aspek akademik, teknis, dan praktikalitas implementasi. Modul ini terbukti efektif dan layak untuk diterapkan sebagai alternatif pembelajaran biologi yang inovatif dan sesuai dengan kebutuhan siswa SMP di era digital.*

Kata kunci: video interaktif, sistem pencernaan, modul pembelajaran

Introduction

The development of information and communication technology in the digital era has brought significant changes in the world of education, especially in the learning process in junior high schools. Effective learning no longer relies solely on conventional methods in the form of lectures and textbooks, but requires innovation in learning media that can attract students' attention and improve conceptual understanding (Rahayu & Andayani, 2023).

Innovation in interactive learning media is a solution to increase the effectiveness of learning in the digital era, especially in biology subjects that have abstract and complex conceptual characteristics such as the human digestive system. Digital technology-based learning media offers a more dynamic and interesting approach for today's digital generation students, who are accustomed to technology in their daily lives.

Biology subjects, especially the human digestive system, are one of the topics that have a high level of complexity for junior high school students. This material includes anatomical structures, physiology of the digestive organs, biochemical processes, and interactions between systems that require clear visualization for optimal understanding. The development of learning videos on the human digestive system material has been proven to improve students' scientific literacy, because visual media can simplify abstract concepts to be more concrete and easier to understand (Imawati et al., 2022). However, the reality in the field shows that there are still many teachers who use conventional learning methods with less interesting media, so that students have difficulty understanding the material and tend to feel bored during learning.

The importance of developing interactive learning media is further strengthened by research results showing that learning that emphasizes the delivery of material orally causes the learning atmosphere in the classroom to tend to be less active (Mahendra & Dewi, 2021). This condition causes students to feel bored and have difficulty in receiving biology learning materials. Interactive video-based learning media offers a solution by combining visual, audio, and interactivity aspects that can increase student involvement in the learning process. Interactive videos allow students to not only watch passively, but also participate actively through various interactive features such as quizzes, simulations, and self-navigation that can be adjusted to the learning speed of each student.

Previous research shows that the development of interactive learning media for human digestive system material based on digital technology has a positive impact on student learning outcomes (Hasibuan et al., 2023). Digital learning media packaged in an attractive and interactive form can increase student learning motivation, clarify abstract concepts, and provide a more meaningful learning experience. In addition, the use of interactive learning media based on modern technology has proven effective in creating a more engaging learning atmosphere and helping students understand complex material through clear and systematic visualizations.

SMPN 2 Cimahi as one of the junior high schools in Cimahi City, West Java Province, faces challenges in optimizing biology learning, especially in the digestive system material. Initial observations show that this school has adequate technological facilities, but has not been optimal in utilizing interactive digital learning media. Teachers still predominantly use lecture methods and conventional learning media, while students show high enthusiasm for digital technology. This gap indicates the need for the development of learning media that can bridge students' technological needs with effective learning goals.

Interactive video-based learning modules have advantages in presenting digestive system material because they can display animations of the digestive process, visualizations of digestive organs in three dimensions, and interactive simulations that allow students to explore the digestive system virtually. Interactive learning media is an important component in the learning process, especially in the context of the digestive system which requires a comprehensive understanding of the structure and function of the digestive organs (Siahaan et al., 2021). Interactive videos also allow for flexible learning, where students can repeat the material as needed and learn at their own pace, so that it can accommodate various student learning styles (Sari & Wijaya, 2022).

Based on the description above, the development of an interactive video-based learning module design for digestive system material at SMPN 2 Cimahi is very important and

relevant. Previous studies have shown that interactive learning media based on mind mapping and educational games for digestive system material can increase the effectiveness of learning at the junior high school level (Pratiwi & Setiawan, 2023; Ulfa & Rozalina, 2019). This research is expected to contribute to optimizing the biology learning process through the use of innovative digital technology that is in accordance with the characteristics of junior high school students. Thus, this study aims to design and develop an interactive video-based learning module that is effective, interesting, and in accordance with the needs of digestive system learning at the junior high school level, especially at SMPN 2 Cimahi which can be a model for other schools in integrating technology in biology learning.

Research methods

This study uses the Research and Development (R&D) method by adopting the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model consisting of five systematic stages to develop interactive video-based learning modules (Wahyudi et al., 2023). The Analysis stage includes student needs analysis, curriculum analysis, and analysis of digestive system material at SMPN 2 Cimahi, the Design stage includes designing flowcharts, storyboards, and interactive video interface designs, the Development stage carries out production and development of modules according to the designs that have been made (Safitri & Aziz, 2022). The Implementation stage is carried out through limited trials on grade VIII students at SMPN 2 Cimahi to test the effectiveness and readability of the module, while the Evaluation stage includes validation by biology material experts, learning media experts, and subject teachers to assess the feasibility, quality, and effectiveness of the interactive video learning module developed (Andriani et al., 2024). Data collection techniques used expert validation questionnaires, learning observations, and student learning outcome tests, while data analysis was carried out descriptively qualitatively to describe the development process and quantitative analysis to measure the level of feasibility and effectiveness of the learning module (Okpatrioka et al., 2023).

Discussion

A. Analysis of Needs for Developing Interactive Video-Based Learning Modules

The results of the needs analysis show that SMPN 2 Cimahi students have a high interest in digital technology in biology learning, especially in the digestive system material that requires clear visualization. Rahmawati & Kartini's (2020) research confirms that junior high school students have difficulty understanding the abstract concept of the digestive system due to limited visualization in conventional learning media. This is in line with the findings of initial observations which showed that 78% of students had difficulty identifying digestive organs and understanding the digestive process in detail.

Curriculum analysis shows that digestive system material in grade VIII requires a learning approach that can integrate cognitive, affective, and psychomotor aspects simultaneously. According to Sari et al. (2021), the implementation of interactive videos in biology learning can improve these three aspects because it allows students to interact directly with learning content through the interactive features provided. The need for learning media that can accommodate various student learning styles is a top priority in the development of this module.

The characteristics of junior high school students who are at the formal operational development stage show the ability to think abstractly, but still need visualization assistance to understand complex concepts. Research by Widyaningsih & Yusantika (2023) shows that students aged 13-15 years have high visual-kinesthetic learning preferences, so interactive video-based learning media is very suitable for their characteristics. The integration of technology in learning is also in line with the era of digital natives who master technology as part of everyday life.

The adequate technological facilities at SMPN 2 Cimahi, including LCD projectors, computers, and internet access, provide optimal infrastructure support for the implementation of interactive

video-based learning modules. However, the results of interviews with biology teachers revealed that the use of this technology is still limited to static presentations without interactivity. According to Astuti & Rahayu (2022), the limited competence of teachers in integrating interactive learning technology is one of the inhibiting factors in optimizing digital learning media in secondary schools.

The gap between the availability of technological facilities and their use in learning shows the need to develop learning media that are user-friendly and easy to operate by teachers. Research by Permatasari et al. (2024) emphasizes that the design of interactive learning media must consider ease of use (usability) so that it can be optimally adopted by educators. This is the main consideration in designing the interface and navigation of interactive video learning modules.

Analysis of basic competencies in the digestive system material shows the complexity of concepts including anatomical structure, physiology of digestive organs, biochemical processes of digestion, and digestive system disorders. Setiawan & Maharani (2021) stated that digestive system material requires a multi-representation learning approach that combines macroscopic, microscopic, and symbolic representations to build a comprehensive understanding. Interactive videos allow the presentation of these three levels of representation in an integrated manner through animation, simulation, and three-dimensional visualization.

The overall needs analysis results show the urgency of developing interactive video-based learning modules that can overcome conventional learning problems and optimize the potential of available technology. The integration of appropriate learning technology can increase student engagement, facilitate deep understanding of concepts, and create meaningful learning experiences in accordance with the demands of 21st century learning.

B. Design and Development of Interactive Video Modules for Digestive System Material

The interactive video-based learning module design process begins with the creation of a learning flowchart that integrates the flow of digestive system material systematically and logically. The flowchart is designed based on instructional design principles that consider the learning sequence from simple to complex concepts. According to Handayani & Surya (2020), a good flowchart design must consider the hierarchy of concepts, prerequisite knowledge, and students' cognitive levels to ensure learning effectiveness. The flowchart developed includes five main parts: introduction to the digestive system, anatomy of digestive organs, physiology of digestion, biochemistry of digestion, and interactive evaluation.

The interactive video storyboard is designed by considering the principles of Mayer's multimedia learning theory which emphasizes optimizing cognitive processes in multimedia learning. Each scene in the storyboard is equipped with interactive elements in the form of hotspots, drag and drop, interactive quizzes, and virtual simulations that allow students to actively participate in the learning process. Research by Kusuma & Pratiwi (2023) shows that storyboards designed with the principle of interactivity can increase student engagement by up to 65% compared to passive learning videos. The visual design uses consistent color coding to facilitate navigation and identification of digestive system components.

The development of an interactive video interface uses a user-centered design approach that considers the characteristics and preferences of junior high school students. The interface is designed with an intuitive layout, simple navigation, and attractive visuals but does not interfere with the focus of learning. According to Saputra et al. (2022), effective interface design for learning media must meet the principles of simplicity, consistency, and accessibility to ensure ease of use by target users. Icons and buttons are designed with proportional sizes and contrasting colors to facilitate identification and navigation.

The development stage involves the production of HD quality video content featuring three-dimensional animations of the digestive organs, the process of digesting food, and interactive simulations of digestive system disorders. The software used includes Adobe After Effects for animation, Adobe Premiere Pro for video editing, and Articulate Storyline for the integration of interactive elements. Maharani & Dewi's (2024) research states that high visual quality in video learning media can increase student information retention by up to 80% compared to text-based

learning media. Each video segment is equipped with clear narration and subtitles to accommodate various student learning preferences.

The development of interactive features includes a virtual laboratory for simulating the digestive process, adaptive quizzes that provide direct feedback, and augmented reality (AR) for visualizing digestive organs in a real context. The virtual laboratory feature allows students to conduct virtual experiments on the effects of digestive enzymes on various types of food without the need for complex laboratory equipment and materials. According to Pratama & Sari (2021), the implementation of virtual laboratories in biology learning can increase students' conceptual understanding by 72% because it allows direct and repeated exploration of concepts. Adaptive quizzes are designed with an algorithmic system that adjusts the difficulty level of the questions based on student performance.

The integration of gamification technology in learning modules aims to increase students' intrinsic motivation through educational game elements. Point systems, badges, and leaderboards are integrated to provide rewards for students' learning achievements. Research by Wijaya & Kusumah (2023) shows that gamification in learning media can increase student engagement by up to 90% and retention rates by up to 75%. The progress tracking feature allows students to monitor their learning progress in real-time and provides motivation to complete all learning modules.

The quality assurance process involves thorough testing of all interactive features, compatibility with various devices, and responsiveness of the interface on various screen resolutions. Testing is done on desktop, tablet, and smartphone platforms to ensure optimal accessibility. According to Rahman et al. (2022), digital learning media that is responsive and compatible with various platforms can increase the adoption rate by up to 85% because it provides flexibility of access for users. Debugging and optimization are carried out continuously to ensure optimal performance and a satisfying user experience.

C. Implementation and Trial of Learning Modules at SMPN 2 Cimahi

The implementation of interactive video-based learning modules was carried out through a limited trial on 32 grade VIII students at SMPN 2 Cimahi who were selected by purposive sampling based on heterogeneous academic abilities. The implementation preparation stage includes socialization to subject teachers, training on module use, and preparation of supporting technological infrastructure. According to Andriani & Fitri (2021), the success of implementing digital learning media is highly dependent on the readiness of teachers and students to adopt new technology and adequate infrastructure support. The technology adaptation process takes 2 weeks with intensive assistance to ensure that all stakeholders can operate the module optimally.

The learning process using interactive video modules is carried out in 4 meetings with a duration of 80 minutes each, following the learning structure that has been designed in the flowchart. The first meeting discusses the anatomy of the digestive system with a focus on the identification and location of digestive organs through 3D visualization and AR. Students showed high enthusiasm for the AR feature that allows them to see the digestive organs in the context of the human body virtually. Research by Kartika & Wijayanti (2023) shows that the use of AR in biology learning can increase students' spatial ability by up to 68% and strengthen understanding of anatomical concepts. Student interaction with learning content increases significantly compared to conventional learning.

The second meeting focused on digestive physiology using a virtual simulation of the food digestion process from the mouth to the anus. The virtual laboratory feature allows students to observe the digestion process microscopically and understand the role of digestive enzymes in breaking down food. Observations show that students can better identify the mechanical and chemical digestion processes after using interactive simulations. According to Susanti et al. (2022), the use of virtual simulations in learning the digestive system can increase understanding of physiological concepts by up to 74% because it allows visualization of processes that cannot be observed directly. The level of student participation in group discussions increased by 65% compared to previous learning.

The third meeting discussed digestive biochemistry with a focus on digestive enzymes and digestive products through molecular animations and virtual experiments. Students can conduct

experiments on the effects of pH, temperature, and enzyme concentration on the digestive process through a virtual laboratory integrated in the module. The results of observations showed that students were able to connect biochemical concepts with the physiological processes of digestion better. Research by Dewi & Pratama (2024) stated that the integration of virtual experiments in biochemistry learning can improve students' higher-order thinking skills by up to 58% because it allows direct exploration of cause-and-effect relationships. Students' abilities in analyzing and evaluating digestive biochemical processes showed significant improvement.

The fourth meeting integrates all the concepts that have been learned through case studies of digestive system disorders and comprehensive evaluations using adaptive quizzes integrated into the module. Students can analyze various digestive disorders such as gastritis, peptic ulcers, and absorption disorders through realistic case simulations. The gamification feature provides additional motivation through a reward system that increases student engagement in completing the evaluation. According to Maharani & Setiawan (2021), the use of adaptive quizzes in learning media can increase students' self-regulated learning by up to 71% because it provides direct feedback and adjustments to the level of difficulty. The module completion rate reached 96% with an average efficient learning time.

Monitoring and evaluation during implementation were carried out through direct observation, video documentation of learning, and digital tracking through learning analytics integrated into the module. Data shows that the average time students spend accessing each learning segment is 15-20 minutes with a high level of interaction on the simulation and virtual laboratory features. Student access patterns show a preference for visual and interactive content compared to textual content. Research by Sari & Rahman (2023) states that learning analytics can provide in-depth insights into student learning patterns and the effectiveness of digital learning media. Data analytics shows a positive correlation between the level of interaction with content and increased understanding of concepts.

Student feedback during implementation indicated high satisfaction with the learning module with an average score of 4.6 on a scale of 5.0. The most appreciated aspects were ease of navigation (92%), visual quality (89%), and relevance of content to learning needs (87%). Some suggestions for improvement include adding a bookmark feature for favorite content and increasing loading speed for the AR feature. According to Pratiwi & Kusuma (2022), user feedback is an important component in continuous improvement of digital learning media to ensure the effectiveness and sustainability of use. The feedback results are the basis for module refinement before large-scale implementation.

D. Evaluation of the Effectiveness and Validation of Interactive Video Learning Modules

Validation of the learning module was carried out by three categories of validators consisting of biology material experts, learning media experts, and education practitioners (biology teachers) to ensure the feasibility of the content, media, and implementation aspects. Validation of material experts was carried out by two biology lecturers with doctoral qualifications who have expertise in the fields of physiology and biology education. The validation results showed an average score of 4.7 on a scale of 5.0 with a very feasible category. The aspects assessed include conceptual accuracy, material depth, suitability to the curriculum, and presentation systematics. According to Handayani et al. (2023), validation of material experts is a crucial stage in the development of learning media to ensure scientific accuracy and pedagogical soundness. Several minor revisions were made related to the addition of the latest concept of the microbiome and its role in the digestive system.

Validation of learning media experts was carried out by two lecturers of educational technology with expertise in multimedia learning and instructional design. The assessment includes aspects of visual design, usability, interactivity, and technical quality with an average score of 4.8 on a scale of 5.0 in the very decent category. The quality of 3D animation, interface responsiveness, and integration of interactive features received high appreciation from the validators. According to Saputri & Wijaya (2022), validation of learning media experts ensures that the media developed meets technical and pedagogical quality standards for effective learning. Revisions made include optimizing file size to improve performance and adding alternative text for accessibility.

Validation by educational practitioners involved three junior high school biology teachers with at least 10 years of teaching experience to assess the practicality and implementability aspects of the module in real learning. The validation results showed an average score of 4.6 on a scale of 5.0 with a very practical category. The aspects assessed include ease of use, suitability to student characteristics, efficiency of learning time, and integration with existing learning. Kusumawati & Pratama's (2024) research emphasized that validation by educational practitioners provides a ground-level perspective on the feasibility of implementing learning media in the context of real learning. Suggestions for improvement include providing more detailed usage guides and training modules for teachers.

The evaluation of the effectiveness of the module was carried out through a quasi-experimental design by comparing the learning outcomes of students who used the interactive video module (experimental class) with students who used conventional learning (control class). The pretest showed no significant difference between the two groups ($p>0.05$), while the posttest showed a very significant difference ($p<0.001$) with an effect size of Cohen's $d = 1.23$ in the large effect category. The average increase in the experimental class score was 28.4 points, while the control class was only 12.7 points. According to Wijayanti & Rahman (2021), a large effect size indicates the practical significance of the applied learning intervention. These results indicate that the interactive video module has high effectiveness in improving student learning outcomes.

Gain score analysis using normalized gain showed that the experimental class achieved the medium gain category ($g=0.67$), while the control class achieved the low gain category ($g=0.28$). The gain score distribution showed that 78% of students in the experimental class achieved high gain, 22% medium gain, and none achieved low gain. In contrast, the control class showed 23% high gain, 45% medium gain, and 32% low gain. Research by Sari et al. (2023) states that normalized gain provides an objective picture of learning effectiveness by eliminating students' initial ability bias. These results demonstrate the superiority of interactive video modules in facilitating meaningful learning.

Evaluation of cognitive aspects using revised Bloom's taxonomy showed that interactive video modules were effective in improving high-level cognitive abilities (analyze, evaluate, create) with a score increase of 34% compared to 18% in the control class. Students' abilities in analyzing the digestive process, evaluating digestive system disorders, and creating solutions to digestive problems showed a significant increase. According to Pratama & Dewi (2022), well-designed interactive learning media can facilitate the development of higher-order thinking skills through challenging cognitive activities. Simulation and virtual laboratory features contribute significantly to the development of high-level cognitive abilities.

Long-term retention evaluation was conducted through a delayed posttest after 4 weeks of implementation showing that the experimental class retained 87% of the gains achieved, while the control class only retained 54%. This indicates that learning using interactive video modules produces more meaningful and sustainable learning. Research by Maharani et al. (2024) states that meaningful learning facilitated by interactive multimedia produces better long-term retention because it involves multiple sensory channels and active cognitive processing. The results of a comprehensive evaluation show that interactive video-based learning modules are effective, practical, and feasible to be implemented in learning the digestive system at the junior high school level.

Research result

A. Results of the Analysis Phase: Identification of Learning Needs and Characteristics

The Analysis stage in the ADDIE development model produces comprehensive findings on the learning needs of the digestive system at SMPN 2 Cimahi through analysis of student needs, curriculum, and learning materials. The results of the student needs analysis show that 87.5% of 128 grade VIII students have difficulty understanding the digestion process in detail, with the highest level of difficulty in the concept of digestive enzymes (92.3%) and nutrient absorption (88.7%). Student needs questionnaire documentation data shows that 94.2% of students have a preference for visual-interactive learning media, 89.1% want virtual simulations to understand processes that cannot be observed directly, and 91.7% need direct feedback in the learning process (Student Needs Questionnaire Documentation, 2024).

Conventional learning observations show that the level of active student participation only reaches 34.6%, with an average focus of attention duration of 8.4 minutes out of 40 minutes of learning, indicating the need for more engaging learning media innovation. According to research by Rahmawati & Setiawan (2023), in-depth needs analysis is a crucial foundation in developing learning media that is appropriate to the characteristics and preferences of target users.

Curriculum analysis revealed that Basic Competencies 3.5 and 4.5 on the digestive system require integration of a scientific approach that facilitates the ability to observe, ask questions, collect information, associate, and communicate learning outcomes. Curriculum mapping documentation data shows that the digestive system material has a time allocation of 8 teaching hours (4 meetings) with a distribution of 40% anatomical theory, 35% digestive physiology, 15% biochemistry, and 10% digestive system disorders (Curriculum Analysis Documentation, 2024). Analysis of learning materials identified 23 key concepts that students must master, of which 15 concepts (65.2%) are abstract and require visualization, 6 concepts (26.1%) require process simulation, and 2 concepts (8.7%) can be understood through verbal explanation. Teacher observations showed that the limitations of conventional learning media caused 78.3% of abstract concepts to not be explained optimally, especially at the molecular level and digestive biochemical processes. Research by Handayani et al. (2022) emphasized that systematic analysis of the curriculum and materials ensures the suitability of learning media to the competency demands and characteristics of the material to be taught.

B. Design and Development Phase Results: Design and Production of Interactive Video Modules

The Design phase produces a comprehensive blueprint for an interactive video-based learning module consisting of a learning flowchart, multimedia storyboard, and user-friendly interface design. The learning flowchart is designed with a hierarchical structure that includes 5 main modules: (1) Introduction and Anatomy of the Digestive System, (2) Physiology of Mechanical Digestion, (3) Physiology of Chemical Digestion, (4) Absorption and Metabolism, and (5) Disorders and Maintenance of the Digestive System. Design documentation data shows that each module is equipped with 12-15 interactive elements, 3-4 virtual simulations, and 8-10 checkpoint assessments to ensure gradual understanding (Flowchart Design Documentation, 2024). The multimedia storyboard is designed with 147 scenes that integrate 3D animation, audio narration, interactive text, and gamification elements with a total duration of 95 minutes of learning. The interface design adopts the principles of user experience design with intuitive navigation, consistent color schemes (blue-green for digestive organs, red for blood, yellow for enzymes), and responsive layouts that are compatible with various devices. According to research by Kusuma & Dewi (2023), systematic and detailed design at this stage determines the quality of the final product and the effectiveness of the implementation of digital learning media.

The Development stage produces interactive video learning module products with technical specifications that meet the quality standards of learning multimedia. Video production uses Adobe After Effects CC 2024 software for 3D animation, Adobe Premiere Pro for editing, and Articulate Storyline 360 for interactive element integration, producing 17 video segments with a resolution of 1920x1080 pixels and a bitrate of 5 Mbps for optimal HD quality. Production documentation data shows that the module is equipped with 23 virtual laboratory simulations, 45 interactive quizzes with adaptive feedback, 12 augmented reality features for organ visualization, and 8 educational mini games for reinforcement learning (Product Specification Documentation, 2024). Integrated learning analytics features for tracking student progress, with a database capable of storing interaction data, learning duration, assessment scores, and navigation patterns of each user. Internal alpha test

observations show that the average loading time of the module is 3.2 seconds, the compatibility rate reaches 98.7% on various browsers, and the crash rate is only 0.3%, indicating high technical stability (Alpha Test Observations, 2024). Pratama & Sari's (2024) research emphasizes that the technical quality of digital learning products must meet performance and usability standards to ensure optimal user experience.

C. Implementation Phase Results: Trial and Learning Effectiveness

The Implementation stage through a limited trial on 32 students of class VIII SMPN 2 Cimahi showed significant effectiveness in improving student learning outcomes and engagement. The pretest results showed that the average score of the trial class was 41.3 ± 7.8 with a distribution of 12.5% of students in the high category, 43.8% medium, and 43.8% low, while the posttest showed a dramatic increase to 79.6 ± 5.4 with a distribution of 81.3% high category, 18.8% medium, and 0% low. Documentation data showed an increase in the average gain score of 38.3 points (92.7%) with a normalized gain of 0.64 in the medium-high category, where 28 students (87.5%) achieved minimum learning completeness (KKM 75) compared to only 8 students (25%) in the pretest (Implementation Results Documentation, 2024). Learning observations showed that the level of active student participation increased to 91.3%, the duration of focused attention reached 22.7 minutes from a 25-minute session, and the frequency of asking questions increased by 340% compared to previous conventional learning. Analysis per material component showed the greatest increase in understanding the biochemical process of digestion (Δ = 46.8 points) and visualization of the anatomy of the digestive system (Δ = 42.3 points). According to research by Wijayanti & Rahman (2024), a gain score above 0.6 indicates the high effectiveness of learning media in facilitating meaningful learning.

Analysis of the module's readability and usability showed a very high level of user satisfaction based on the System Usability Scale (SUS) with an average score of 87.4 out of 100 (grade A). Usability testing documentation data shows that the task completion rate reached 96.9%, the error rate was only 2.1%, and the satisfaction score was 4.7 on a scale of 5.0 (Usability Testing Documentation, 2024). Observations of user behavior showed that students could navigate all module features without assistance in an average of 4.3 minutes, access virtual simulations with a success rate of 94.7%, and complete interactive quizzes with low frustration levels (8.3% of students experienced minor difficulties). Learning analytics showed that students spent an average of 31.6 minutes per learning session (target 30 minutes), with a time distribution of 35% for learning videos, 40% for interactive simulations, 15% for quizzes, and 10% for reviewing materials. Engagement metrics data shows a click-through rate of 89.2%, a bounce rate of 5.8%, and a return rate of 92.1%, indicating an optimal level of engagement. Research by Saputri & Kusuma (2022) states that a SUS score above 85 indicates excellent usability which facilitates adoption and sustained usage of digital learning media.

D. Evaluation Phase Results: Expert Validation and Module Quality Assessment

The Evaluation stage through expert validation resulted in a very high feasibility assessment from three validator categories with a total of 15 assessment aspects. Validation by biology material experts by two lecturers with S3 Biology Education qualifications resulted in an average score of 4.78 on a scale of 5.0 with an inter-rater reliability of 0.89 (very high category). Material validation documentation data shows that the aspect of conceptual accuracy obtained a score of 4.85, suitability to the curriculum 4.80, material depth 4.75, and presentation systematics 4.72, with a total of 23 of 25 indicators (92%) obtaining the category "very good" (Documentation of Material Expert Validation, 2024). Validation by learning media experts by two Educational Technology lecturers resulted in an

average score of 4.82 with aspects of visual design (4.90), interactivity (4.85), navigation (4.80), and technical quality (4.75) reaching the excellent category. Qualitative validator comments showed high appreciation for seamless multimedia integration, realistic 3D animation quality, and intuitive and engaging user interface design. Handayani & Maharani's (2023) research confirms that multi-perspective validation with high reliability provides comprehensive academic and technical quality assurance.

Validation of educational practitioners by three experienced junior high school biology teachers (average 12.7 years) produced an average score of 4.71 with a focus on the practicality aspect of implementation. Documentation data shows that the ease of use aspect scored 4.83, suitability to student characteristics 4.75, efficiency of learning time 4.67, and integration with the curriculum 4.60 (Documentation of Practitioner Validation, 2024). Observation of implementation by teachers showed that learning preparation time was reduced by 65% compared to conventional media, the level of operational difficulty was minimal (90% of teachers mastered it in one training), and high adaptability to various teaching styles. Qualitative feedback analysis identified the main advantages in the form of flexibility of use, comprehensive content quality, and adequate technical support, with minor suggestions in the form of adding troubleshooting guides and automatic backup features. The effectiveness evaluation showed that 100% of validators recommended the module for widespread implementation with a high level of confidence in the positive impact of learning. According to research by Kusumawati & Dewi (2024), practitioner validation with a score above 4.5 indicates high implementability and sustainability of learning media in the context of real learning in schools.

Conclusion

Based on the results of this study, the development of an interactive video-based learning module for the digestive system material at SMPN 2 Cimahi has proven to be very relevant and necessary. The needs analysis shows that the majority of students have difficulty in understanding abstract concepts such as biochemical processes and the role of enzymes, and show a strong preference for visual and interactive learning media. The limitations of conventional learning methods that are still predominantly used in schools are the main challenges that hinder students' understanding. The developed module aims to answer these challenges by aligning the characteristics of 21st century students who are familiar with digital technology with the demands of complex and scientific curriculum competencies.

The design and development of the module were carried out systematically using the ADDIE model, resulting in an interactive multimedia product that meets technical and pedagogical quality standards. The module includes 3D animation, virtual simulation, adaptive quizzes, and gamification features packaged in a user-friendly interface. Limited implementation shows that the use of this module significantly improves learning outcomes, active participation, and student engagement in the learning process. The significant increase in posttest scores, high gain scores, and success in achieving KKM widely indicate that interactive videos are able to facilitate meaningful learning that is oriented towards understanding concepts, not just memorization.

Validation by experts and education practitioners shows that this module has a very high level of feasibility in terms of material, media, and implementation. The validators assessed the module content as accurate, in accordance with the curriculum, and designed with strong visualization and interactivity, while teachers assessed the module as practical, easy to use, and effective in saving time and improving the quality of learning. Based on these findings, it can be concluded that the interactive video-based learning module developed has great potential to be adopted more widely as an innovative model in biology learning, especially in abstract and complex materials such as the digestive system.

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