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Interactive E-Modules with Hologram and Text-to-Speech: An Innovative Media for Teaching the Human Excretory System

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ABSTRACT

This research aimed to develop an interactive e-module with hologram and text-to-speech technologies for teaching junior high school science, specifically the human excretory system, in grade VIII. Using an R&D approach based on the Borg and Gall model up to the 7th stage (problem identification, data collection, product design, design validation, product trials, and revision), the e-module was validated by six experts. The study involved students from SMPN 1 Bumi Ratu Nuban Lampung Tengah, including 10 students for small group trials and 30 students for field trials. The results showed that the e-module, with 82% validation from media experts, 92% from content experts, and 88% from language experts, was highly valid. Student trials also indicated that the e-module on animal tissue material was engaging, with a 78% rating in small group trials and 80% in field trials. This study offers a valuable contribution to enhancing education through innovative, technology-based learning media.

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INTRODUCTION

The rapid development of technology and the increasing progress of society have significantly influenced education in Indonesia, from the knowledge of the Industrial Revolution 4.0 era to the current Society 5.0 era (Suherman et al., 2024). This advancement progresses in tandem with science and technology, both of which expand fields with applications and benefits in every aspect of life (Salsabila et al., 2024). Through the use of technology in education, future generations will become academically and emotionally intelligent, skilled, and independent, enabling our country to advance (Solviana, 2020). Therefore, the role of education must continuously adapt to these developments to shape superior human resources. However, without

educational innovation, efforts to improve education standards will fail (Rianti & Setiawan, 2024). To create better human resources, the government has initiated the "Merdeka Belajar" (Freedom to Learn) program, with educators, particularly teachers, serving as the driving force behind it. Schools, teachers, and students all have the freedom to innovate in the learning process (Fitria et al., 2022).

The use of media is one of the innovations that can help achieve learning objectives (Krisna et al., 2024). To engage students' thoughts, feelings, attention, and interest in the learning process, instructional media can be viewed as a channel for conveying messages from the speaker to the receiver during the learning process (Ani Daniyati et al., 2023). The most suitable instructional media for independent learning activities is a module (Yolan et al., 2023). A module is a learning tool that students can use to optimize their learning. The use of modules in teaching is believed to have a high level of success (Erlangga & Dwiningsih, 2024). Module-based instructional media is an educational resource that consists of sub-chapters with related materials that can be studied independently (Parapat et al., 2024).

Along with its development, many modules have transformed into electronic modules, or commonly known as e-modules, where the learning materials are presented in a more engaging and participatory manner (Marinda et al., 2023). The difference between print modules and e-modules is minimal, as it is only visible in the physical form. The components contained within them are identical to those in traditional print modules (Haka et al., 2021). E-modules are created interactively using engaging features, reducing student boredom caused by monotonous learning (Asri & Dwiningsih, 2022). The use of e-modules in the learning process can minimize the amount of paper used and is not limited by time or location, as they are available for free and can be tailored to meet students' needs anytime and anywhere. Interactive e-modules can consist of text, images, audio, and video (Khasanah & Nurmawati, 2021). The use of interactive e-modules can be integrated with other media to create a sequence of learning activities that encompass learning models, teaching methodologies, and diverse content delivery (Solviana et al., 2024).

Hologram-based instructional media is a very intriguing concept. One of the most advanced technologies with applications in many educational fields is 3D holography. With the use of this technology, educators and students will be able to access learning tools that are not available in conventional classrooms (Pratama & Hadi, 2023). By using hologram technology, images, scenes, or a combination of scenes can be displayed in three dimensions (3D), as if they are emerging from

a flat surface (Nabila et al., 2024). The 3D shapes produced have the ability to move and emit sound, allowing information to be communicated in real time or not at all (Adaweyah et al., 2023).

In addition to hologram technology, Artificial Intelligence (AI) has a significant impact on many aspects of life, including learning and education. Text-to-Speech (TTS) is one of the most widely used and increasingly popular AI applications (Sarif & AR, 2024). TTS *is a device that functions to convert text into speech* (Handayani et al., 2023). There are also studies that use TTS to identify text in images and generate audio from it (Putri et al., 2024). In addition to helping students learn foreign languages and pronounce them correctly, TTS technology allows them to process information independently and enhance their understanding while studying (Mubarak & Santoso, 2023). *Online Text-to-Speech offers a variety of synthetic voices, including Indonesian and English languages* (Sherina & Hasnawati, 2023).

Biology is one branch of science within the IPA subject that investigates objects and issues related to natural events. Biology is knowledge that not only includes information but also products, processes, and attitudes (Haka et al., 2020). Based on an interview with one of the science teachers at SMPN 1 Bumi Ratu Nuban Lampung Tengah, on February 9, 2023, it was stated that in science teaching, the instructional media used consists of limited textbooks, which makes it difficult for students due to the scarcity of these books. The teacher also uses instructional media such as PowerPoint presentations (PPT) and videos. Additionally, the teacher employs the lecture method due to the limited availability of teaching materials like modules and interactive modules, making the learning process less effective. Meanwhile, students only receive knowledge references from the teacher.

Based on the results of the student needs survey at SMPN 1 Bumi Ratu Nuban Lampung Tengah, it was found that the instructional media used by teachers still caused difficulties for students in delivering science material, especially on the topic of the human excretory system. As a result, students had difficulty understanding the material on the human excretory system explained by the teacher and considered it to be an abstract topic. In addition to impacting students' understanding of the material, the lack of media to explain the topic also affected the students' daily test results on the human excretory system.

The use of hologram-based e-modules and TTS can address this issue in an innovative manner. Holograms allow students to visualize concepts that are difficult to understand, such as the human excretory system, in three-dimensional forms that move and emit sound. This helps

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reduce the abstract nature of the subject matter, making it easier for students to comprehend and retain the information. Additionally, TTS technology enables students to listen to clear explanations of the material, which can be repeated as needed, thus enhancing their independent understanding. With this combination, e-modules become an effective tool to improve visual and auditory comprehension, providing a more comprehensive and engaging learning experience. The main benefit for students is the ability to learn independently with media that is more interactive and accessible anytime and anywhere, without being limited by time or location. Based on the problem description, this research is important to conduct and is expected to serve as an innovative alternative learning resource that can assist students in learning science, particularly on the topic of the human excretory system.

RESEARCH METHOD

This research was conducted at SMPN 1 Bumi Ratu Nuban Lampung Tengah during the odd semester of 2023/2024. The research design used is the Borg and Gall design. Development research is defined as a design aimed at producing new products through a process of development and product validation (Saputra & Sujatmiko, 2023). This development research aims to create electronic teaching materials that utilize computer software technology in their creation, resulting in a product that can make learning more flexible and interactive. The population used in this study consists of eighth-grade students at SMP Negeri 1 Bumi Ratu Nuban, with a sample of 10 students for the limited-scale test and 30 students for the large-scale test, selected using a simple random sampling technique. The product, developed by the researcher and validated by experts, was then used by students, and the responses to its use were obtained from both teachers and students.

The development procedure follows ten stages from Borg & Gall, which are: 1) Information gathering, 2) Planning, 3) Initial product design, 4) Limited trial, 5) Revision of results, 6) Large-scale product trial, 7) Product revision, 8) Field testing, 9) Final product revision, 10) Final product implementation. However, in this study, only seven stages were used, with adjustments to the steps reinforced by expert Wina Sanjaya (Sanjaya, 2013) namely, as shown in the diagram below:

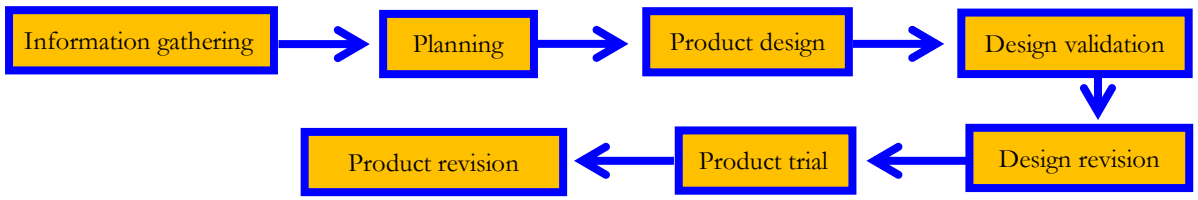

Figure 1. Modified R&D Procedure Steps by Borg and Gall According to the Research

The research follows the ten stages of the Borg & Gall model for development research, but in this study, only seven stages were utilized, with adjustments made based on expert input.

1. Information Gathering: This initial stage involved identifying problems within the school. Information was collected through interviews, surveys, and documentation, including input from both students and educators at SMPN 1 Bumi Ratu Nuban.
2. Planning: In this stage, a detailed plan was developed, including the determination of research objectives and the competencies to be addressed. This stage also involved designing the steps for the development of the interactive e-module.
3. Product Design: At this point, the interactive e-module, incorporating hologram and text-to-speech technologies, was developed. This design included various components such as the cover page, table of contents, competency indicators, and evaluation materials.
4. Limited Trial: The product was initially tested on a small group of students (10 students) to assess usability and gather feedback. The trial aimed to identify any significant flaws or improvements needed.
5. Product Revision: Based on feedback from the limited trial, revisions were made to enhance the e-module's functionality, usability, and content clarity. This revision was guided by the input from media, content, and language experts.
6. Large-Scale Trial: A larger group of 30 students participated in this phase, where the e-module's application was tested on a broader scale. The goal was to determine its effectiveness in the classroom and gather additional insights into its usability.
7. Field Testing: This was the final stage, where the e-module was tested in real classroom settings. Feedback from teachers and students helped refine the product further. Validators played a key role in assessing the media, content, and language, ensuring that all aspects of the module were aligned with educational standards and student needs.

At each stage of the product development, validators, including media experts, content specialists, and language experts, reviewed the product to ensure it met quality standards. These experts provided feedback on visual design, language use, accuracy of content, and pedagogical effectiveness. Their assessments helped to refine the e-module, ensuring it was both educationally effective and engaging for students. The validation instrument blueprints used in this study are presented in Table 1 for content validation, Table 2 for media validation, and Table 3 for language validation.

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Table 1. Expert Validation Criteria for Content Feasibility

No	Aspect	Indicator	Instrument Numbers		Number of Items
			+	-	
1	Content Feasibility	Consistency of application content, core competencies, basic competencies, indicators, and learning objectives	1, 2, 8, 12	3, 4, 5, 7	8
2		Consistency of material with the curriculum	6	18	2
3		Accuracy of the material and media	10	17	2
4		Accuracy of facts and terminology	19	26	2
5		Breadth and clarity of the material	9	23	2
6		Material and practice questions	15	24	2
7		Coherence of the material content	11	22	2
8		Consistency of examples with the material being presented	13	16	2
9		Alignment of indicators and enhancement of students' scientific attitudes	21, 27	25, 34	2
10		Improvement of students' understanding	33	30	2
11		Consistency of images/videos in clarifying the material	14	20	2
12		Alignment with students' cognitive domain development	31, 28	29, 32	2
Total					30

The table outlines Content Feasibility Indicators for evaluating the alignment of educational material with learning objectives, curriculum, and media. It assesses various aspects like content accuracy, clarity, coherence, and alignment with students' cognitive development. This evaluation is crucial for ensuring effective learning content. The next step is the Media Expert Validation, which assesses the quality of media elements used in the materials.

Table 2. Media Expert Validation

No	Aspect	Criteria	Instrument Numbers		Number of Items
			+	-	
1	Quality Aspect	Accuracy in selecting font type and font size	1, 6	3, 5	4
2		Compatibility of background	13	8	2
3		Display of images/videos	32	7	2
4		Display of menu	2, 35	17. 22	4
5		Visual appeal of the display	12	15	2
6		Accuracy in placing images	9	16	2
7	Graphic Aspect	Practicality of using the media	11, 30	18, 37	4
8		Usage instructions	24	4	2
9		Ease of operation	23	19	2
10		Coherence of media	14	10	2
11	Effectiveness Aspect	Improving students' ability	20, 27, 34	21, 26, 34	6
12		Enhancing scientific attitude	36	33	2
13		Suitability with the students	31	39	2
14		Images/videos improving understanding	25	28	2
15		Use of media	29, 40	40	2
Total					40

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The table presents Media Feasibility Indicators, evaluating aspects such as visual quality, graphic design, and media effectiveness. It includes criteria like font selection, background compatibility, image/video display, and media practicality. This thorough evaluation is crucial for ensuring that the media enhances the learning experience. The next step is the Language Expert Validation, which focuses on the language accuracy and clarity in the instructional materials.

Table 3. Language Expert Validation

No	Aspect	Criteria	Instrument Numbers		Number of Items
			+	-	
1	Language Aspect	Use of language in accordance with standard spelling rules (EYD)	1, 17	4, 20	4
2		Cognitive ability of students	9	24	2
3		Language development level of students	3	6	2
4		Language and illustration	2	8	2
5		Consistency and coherence in the use of terminology	18, 21	19, 26	4
6		Use of foreign language	10	12	2
7		Accuracy in the use of punctuation marks	27	22	2
8		Accuracy of sentence structure	15	13	2
9		Presence of ambiguous interpretations	14	11	2
10		Selection of form, color, and size	5, 16	7, 23	4
11		Eliciting a positive response	27	29	2
12		Accuracy in language structure	28	30	2
Total					30

Table 3 presents the Language Expert Validation criteria, which assess the accuracy and clarity of language used in instructional materials. It includes aspects such as adherence to standard spelling rules (EYD), cognitive and language development levels of students, consistency in terminology, and the accuracy of punctuation and sentence structure. The validation process is integral to ensuring that the language used is appropriate for students.

Teacher and student interviews, expert validation questionnaires (media, content, and language), and documentation (photos and research videos) were used to collect data in the study. The questionnaire, in the form of closed-ended questions, was designed using a Likert Scale with five options. The data analysis of the questionnaire was then summarized into percentages using the formula (Sukardi, 2011):

$$Average\ score = \frac{Total\ score}{Highest\ total\ score} x\ 100$$

The feasibility percentage obtained is then interpreted into categories as shown in Table 1 below:

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Table 4. Validation Criteria (Darwis et al., 2020)

No	Quality Score	Feasibility Criteria
1	90% - 100%	Very Valid/Highly Feasible
2	70% - 89%	Valid/Feasible
3	50% -69%	Fairly Valid/Fairly Feasible
4	30% - 49%	Invalid/Not Feasible
5	20% - 29%	Not Valid/Not Feasible

Validation Criteria (Darwis et al., 2020) presents the classification of educational material based on quality scores. A score of 90%-100% indicates very valid and highly feasible, 70%-89% is valid and feasible, 50%-69% is fairly valid and feasible, 30%-49% is invalid and not feasible, and 20%-29% is not valid and not feasible. These criteria assess the material's effectiveness and suitability for educational use.

Data analysis for teacher and student responses was conducted after obtaining the results from the product trial. The scores for each statement from the product trial were averaged and expressed as percentages using the following formula:

$$\%=(\text{Maximum total score}/\text{ Total score})\times 100$$

Where:

- Total score refers to the sum of the scores obtained.
- Maximum total score refers to the highest possible score.

To interpret the results of the product trial, a standardized evaluation scale was used, as shown in Table 5 below:

Table 5. Practicality/Attractiveness Criteria

Interval	Evaluation Criteria
> 84%	Very Good
69% – 84%	Good
52% – 69%	Fair
36% – 52%	Poor

The results of the instrument validation by experts and the student response evaluations from the product trial are necessary to determine the feasibility of the media. This analysis helps assess whether the developed product is suitable for use in the educational setting.

RESEARCH RESULT

After conducting the research, the following procedure for the study on Innovation in Science Learning through Interactive E-Modules with Hologram and Text-to-Speech Technology is explained as follows:

Research And Information Collect

The first stage in developing this Interactive E-Module is information gathering. The results from interviews with science teachers showed that there is a lack of teaching materials, and they rely heavily on printed books and worksheets (LKS). In delivering the material or solving exercises, they still depend on the textbook. It was concluded that interactive learning media is

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crucial to encourage students to increase their interest in learning and to facilitate their understanding of the material on the Human Excretory System. Therefore, the researcher developed interactive learning media with the aim of improving students' learning interest.

Planning

The goal of the research planning phase is to design a product that aligns with specific requirements. By reviewing the K13 curriculum, which includes core competencies, basic competencies, and learning outcomes, the research planning process is conducted. The focus of this research is on the material related to the human excretory system. It is crucial to carry out thorough research planning to ensure the success of the research implementation.

Develoved Preliminary Form Of Product

Utilizing Hologram and Text To Speech technology, the final product is an engaging Interactive E-Module. This E-module, created with the help of Canva and Augmented Reality applications, includes various elements such as a visually appealing cover page design, an introduction, core competencies and basic competencies, user instructions, lesson materials, exercises, quizzes, evaluations, references, author biography, and a useful glossary.

By simply scanning the barcode on the material with a smartphone equipped with Augmented Reality applications, students can access holographic visuals and utilize the Text-to-Speech feature. This application also includes an easy-to-use button to facilitate students in operating the application, along with informative explanations of the hologram images and the Text-to-Speech feature. Several hologram and Text-to-Speech features included in the e-module are presented in Table 6.

Table 6. Examples of Features Included in the E-Module

Display	Description
	This display allows us to understand what Text to Speech is by clicking the play logo on the available image. Then, the Text to Speech feature will be activated.
	This display shows the initial screen of the AR Biology application created by the researcher to access the Hologram and Text To Speech features.

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Display	Description
  	This hologram display is available in the AR Biology application. It can be accessed by scanning the barcode provided on this display, allowing us to view how the created hologram appears.
	This barcode is used to access the hologram and Text to Speech features and can be used in the AR Biology application that was created.

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Preliminary Field Testing

The design validation process includes an assessment of the product design developed, specifically the Interactive E-Module designed to enhance Science learning in Grade VIII SMP through the use of Hologram and Text to Speech. The purpose of this evaluation is to identify errors that need improvement. At this stage, the product is validated by media experts, content experts, and language experts, as illustrated below:

Media Expert

Media expert validation was conducted to test the feasibility of the module by two media experts. The results of the validation by both experts are shown in Table 3.

Table 7. Feasibility Results of the Module by Media Experts

No	Assessment Aspects	Validator 1		Validator 2	
		Score	Criteria	Score	Criteria
1	Quality Aspect	77%	SL	88%	SL
2	Graphics Aspect	100%	SL	88%	SL
3	Effectiveness Aspect	77%	SL	100%	SL
	Total	77%	SL	88%	SL
Total Overall 82%					

Based on Table 3, it can be seen that the quality aspect received a percentage score of 77% from 16 questions, the graphic aspect received a score of 100% from 10 questions, and the effectiveness aspect received a score of 100% from 10 questions. The score of 77% is derived from 14 questions. The average of these three aspects is 82%, with the validation result categorized as "very feasible."

Content Expert

Two content experts validated the E-module content, as shown in Table 4:

Table 8. Content Expert Validation Results After Revision

No	Assessment Aspects	Validator 1		Validator 2	
		Score	Criteria	Score	Criteria
1	Content Feasibility	84,37%	SL	85%	SL
2	Suitability	75%	L	76%	L
3	Language Use	87%	SL	88%	SL
	Results	93%	SL	90%	SL
Total overall 92%					

Based on Table 4, it can be seen that the content aspect received a percentage score of 84.37%, the alignment with the learning model aspect received a score of 75.25%, and the language aspect received a score of 87.5%. Overall, the percentage score for these three aspects in the "very feasible" category is 92%.

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Language Expert

Two language expert validators conducted the language validation by reviewing the content of the E-module. The validation results from both validators are presented in Table 5 below:

Table 9. Results of Language Expert Validation After Revisions

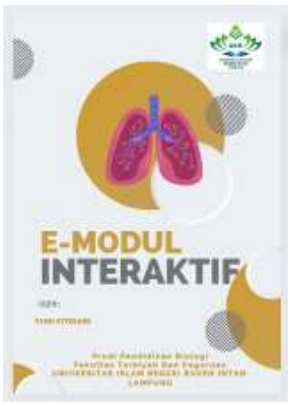
No	Assessment Aspects	B1		B2	
		Score	Criteria	Score	Criteria
1	Clear	79%	L	80%	L
2	Communicative	75%	L	76%	L
3	Dialogic and Interactive	81%	L	85%	L
4	Suitability with Student Development	90%	SL	90%	SL
	Results	84%	SL	91%	SL
Total overall score 88%					

Based on Table 5, the clarity aspect scored 79.16%, the communicative aspect scored 75%, the dialogic and interactive aspect scored 81.25%, and the alignment with student development aspect scored 90%. Considering these four aspects, which consist of 11 items, the overall score is 88%, categorized as "very feasible."

Main Product Revision

The results of the limited review will be revised after the initial or limited review stage is completed. At this stage, we make product improvements based on feedback and recommendations from experts in language, content, and media. Once the product has been validated, revisions will be made accordingly. After the product is revised, the product development process can proceed to the next stage, which is product testing.

Table 10. Revisions Based on Product Testing Results

Revision	Visual		Description
	Before revision	After revision	
Media Expert			The front and back cover revisions, based on feedback from the media expert verifier, include the addition of the curriculum and the inclusion of the class level.

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Revision	Visual		Description
	Before revision	After revision	
			Displaying the glossary before and after the revision. Before the revision by the validator, the glossary was not available, and the documentation was incomplete. After the revision, the alphabetical order is clear, and the material on elasticity modulus is also adequately included.
			The display of the e-module usage before and after the revision. To make this display more attractive, the validator changed the word "*petunjuk*" (instructions) to "*pedoman*" (guidelines).
Media Expert			The presentation of the device before and after the validator's correction. The initial screen only displayed an understanding of the material. After the revision, a brief explanation of the excretory system material was added, followed by detailed information about the human excretory system.
Content Expert			The material initially displayed the content directly, without being introduced beforehand, and was shown before being modified by the reviewer. After being revised by the verifier, the module now starts with an introduction to the material.

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Revision	Visual		Description
	Before revision	After revision	
Language Expert			In the display of the material discussed before being corrected by the validator, this screen only showed the material. After being corrected by the validator, the learning activities were added.

Small Group Trial

The revised product that passes the validation stage will be tested in Class VIII at SMP Negeri 1 Bumi Ratu Nuban. The purpose of this small-group trial is to gather student feedback on their interest in the interactive media. A small group consisting of 10 selected students will be tested using a simple random sampling technique. The experiment involves providing instructional materials, followed by a survey to assess the appeal of the learning content. The questionnaire consists of two aspects: the media aspect and the content aspect. Students will also be given the opportunity to voice their critiques and suggestions for the product.

Table 11. Results of Small Group Trial

No	Response	Total Score	Maximum Score	Percentage	Criteria
1	A1	74	104	71%	Good
2	A2	87	104	84%	Very Good
3	A3	71	104	68%	Good
4	A4	76	104	73%	Good
5	A5	79	104	76%	Good
6	A6	74	104	71%	Good
7	A7	82	104	79%	Good
8	A8	91	104	88%	Very Good
9	A9	91	104	88%	Very Good
10	A10	88	104	85%	Very Good
Total Score:		813			
Maximum Total Score:		1.040			
Average Percentage:		78%			
Criteria		Good			

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Based on Table 7, the results of the small group trial assessed the media aspects and content components of the product. The overall score for the small group trial (limited trial) was 78%, which falls under the "Good" category.

Field Trial (Large-Scale Testing)

The field experiment was conducted in Class VIII of SMA Negeri 1 Bumi Ratu Nuban with a total of 30 students in the class. The test involved providing students with educational material to view and study, followed by asking students questions to assess the attractiveness of the educational content.

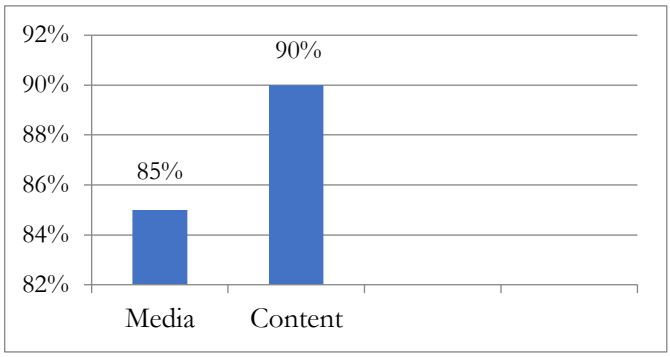

Figure 2. Graph of Field Group Test Results

Figure 2 shows the highest percentage in the content section at 90%, with an overall average response of 80% categorized as "very interesting," indicating that this product received positive responses in the broader-scale testing.

Operational Product Revision

Based on the overall results of the trials, expert evaluations, and responses to the developed product, the final revised version of the e-module can be accessed via the following link: **"CANVA".** Meanwhile, to access the hologram and text-to-speech features, please use the following link: **"DRIVE".**

To download the AR Biology application, use the provided link. Once the application is installed, you can scan the barcode located in the product design section. After scanning, the AR Biology application will display a hologram and text-to-speech features.

DISCUSSION

The product, as a digital learning medium that is engaging, interactive, easily accessible, understandable, beneficial, and free, is essential for students to support their learning process both in the classroom and during independent study at home. It is also flexible, allowing access from

any location, especially when equipped with hologram and text-to-speech features. One of the advantages of interactive learning media supported by holograms and text-to-speech is that they can be used anytime and anywhere as long as there is an internet connection. This learning support is accessible at any time and from any place.

Students and teachers have responded very positively to this product, which is effective as a teaching aid in schools. The development of these electronic components as a learning program is highly appealing due to their ease of access from anywhere. It is consistently beneficial as it facilitates understanding topics related to the human excretory system. Through this educational program, students and educators are not only focused on traditional school textbooks but are also embracing rapid advancements in education.

This media aids students in easily comprehending the information conveyed by teachers because it provides more comprehensive and engaging content. The available learning materials are highly supportive in offering in-depth knowledge about the human excretory system.

In the context of educational innovation, incorporating technology such as holograms and text-to-speech (TTS) into learning materials offers a promising solution to improve engagement and understanding. This study, which developed an interactive e-module with hologram and TTS features to teach the human excretory system, demonstrates the effectiveness of these technologies in enhancing students' learning experiences. To further strengthen these findings, it is beneficial to compare the results with similar studies that have explored the use of technology in education. By comparing the effectiveness of hologram and TTS technology with other technological interventions, we can better understand the specific advantages these tools bring to the learning process.

Ardiansyah Ridsa, et al (2020), conducted a study on the effectiveness of 3D hologram-based learning media in improving student learning outcomes in biology education at SMA Negeri 2 Majene. The study revealed that students using hologram-based media performed better than those using traditional textbooks, indicating that hologram technology enhanced their understanding of complex biological concepts. Similarly, this study found that the integration of hologram technology in the e-module significantly helped students grasp the material related to the human excretory system. The 3D visual representation provided by the hologram allowed students to view biological structures in a more interactive and immersive way, thereby improving their comprehension.

Yudhistiro & Silalahi (2021), focused on the use of text-to-speech technology in language learning, specifically in an English language laboratory. His findings showed that TTS technology significantly aided students in improving their listening and pronunciation skills by converting written text into spoken words. In this study, the use of TTS technology within the e-module similarly supported students by providing auditory reinforcement of the material. This feature helped students, particularly those with learning difficulties or auditory preferences, to better understand the content by listening to it repeatedly, reinforcing their learning process.

By comparing your findings with these studies, it is evident that the combination of hologram and TTS technologies provides unique benefits in educational contexts. These technologies not only enhance student engagement and interaction with the material but also cater to diverse learning styles, offering a more inclusive and accessible approach to learning.

The product, as a digital learning medium that is engaging, interactive, easily accessible, understandable, beneficial, and free, is essential for students to support their learning process both in the classroom and during independent study at home. It is also flexible, allowing access from any location, especially when equipped with hologram and text-to-speech features. One of the advantages of interactive learning media supported by holograms and text-to-speech is that they can be used anytime and anywhere as long as there is an internet connection. This learning support is accessible at any time and from any place.

Students and teachers have responded very positively to this product, which is effective as a teaching aid in schools. The development of these electronic components as a learning program is highly appealing due to their ease of access from anywhere. It is consistently beneficial as it facilitates understanding topics related to the human excretory system. Through this educational program, students and educators are not only focused on traditional school textbooks but are also embracing rapid advancements in education.

This media aids students in easily comprehending the information conveyed by teachers because it provides more comprehensive and engaging content. The available learning materials are highly supportive in offering in-depth knowledge about the human excretory system. To strengthen these findings, it is beneficial to compare them with similar studies that utilize technology in education. For instance, previous research on the use of hologram and text-to-speech technology in educational settings has shown that these tools can significantly enhance engagement and comprehension. By comparing the effectiveness of holograms and TTS with

other technologies, we can gain deeper insights into why and how these technologies are particularly effective in the context of teaching complex biological systems.

In terms of learning theory, the integration of hologram and TTS technologies aligns closely with constructivist learning theory, which emphasizes the importance of active learning and the construction of knowledge through experience. Constructivist theorists such as Vygotsky and Piaget suggest that learners build understanding by interacting with their environment and engaging in problem-solving activities (Piaget, 1973; Vigotsky, 1978). In the context of your study, holograms provide a visual and interactive representation of the human excretory system, allowing students to actively engage with the material and construct knowledge in a more hands-on way. Similarly, TTS technology supports auditory learners by providing verbal explanations, reinforcing the material through multiple sensory channels.

Moreover, the technology-based learning model, which integrates multimedia tools to enhance learning, also supports the effectiveness of the e-module. According to Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2005), students learn more effectively when they are presented with both visual and auditory stimuli. The hologram and TTS features used in your e-module cater to this principle, helping students process and retain information by engaging both their visual and auditory senses. This multimodal approach not only supports diverse learning styles but also ensures a deeper understanding of complex topics such as the human excretory system.

By incorporating these theories, we can better understand the underlying principles that make hologram and TTS technologies effective in improving student engagement and comprehension. These technologies provide an interactive, multimodal learning experience that is aligned with both constructivist and technology-based learning models, making them highly effective tools for modern education.

CONCLUSION

This study developed an interactive e-module incorporating Hologram and Text-to-Speech (TTS) technologies to enhance junior high school students' understanding of the human excretory system. The findings highlight the novelty and innovation of combining these two technologies in a biology learning context, which has not been widely applied, especially in teaching complex biological systems. The use of holograms offers students a 3D, interactive visual representation of the human excretory system, making the material more accessible and engaging. TTS technology

supports auditory learners by providing verbal explanations, enhancing comprehension, and enabling students to engage with the content independently. This innovative approach not only improves students' understanding but also introduces a new interactive learning experience, merging visual and auditory elements in a way that is rarely seen in biology education. The successful integration of holograms and TTS technology represents a significant step forward in utilizing digital learning tools to improve the effectiveness of science education.

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