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Visual, audio, and kinesthetic students' learning independence: Improvement through the development of augmented reality media

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Abstract: Technology has provided new educational opportunities, but the implementation could be more optimal. Learning facilities that remain focused on conventional methods often need more learners with the Visual, Audio, and Kinesthetic (VAK) learning style. This study aimed to evaluate the effectiveness of this learning media in improving learning achievement and information retention, focusing on visual, audio, and kinesthetic learning styles. This research was a research development that used the Lee & Owens model, which consisted of analysis, design, development, implementation, and evaluation. The validation result of the media was 98.5%, material validation was 100%, and learning device validation was 100%. The results of the implementation of self-assignment in the control class obtained an average of 78.8 and in the experimental class 90.5. The research concluded that learning media is practical and can help facilitate biology learning in visual, audio, and kinesthetic learning styles.

Keywords: Augmented reality, torso, independent learning

Abstrak: Teknologi telah membuka peluang baru dalam pendidikan, tetapi implementasinya seringkali masih kurang optimal. Fasilitas pembelajaran yang masih terpusat pada metode konvensional tidak selalu memenuhi kebutuhan peserta didik dengan gaya pembelajaran Visual, Audio, dan Kinestetik (VAK). Penelitian ini bertujuan untuk mengevaluasi efektivitas media pembelajaran ini dalam meningkatkan prestasi belajar dan retensi informasi dengan mengutamakan gaya belajar visual, audio, dan kinestetik. Penelitian ini merupakan penelitian pengembangan yang menggunakan model Lee & Owens yang terdiri dari analisis, desain, pengembangan, implementasi, dan evaluasi. Hasil validasi media 98,5%, validasi materi 100%, dan validasi perangkat pembelajaran 100%. Hasil implementasi penugasan mandiri pada kelas kontrol mendapatkan rerata 78,8 dan di kelas eksperimen 90,5. Kesimpulan penelitian media pembelajaran praktis dan dapat membantu memfasilitasi pembelajaran biologi pada gaya belajar visual, audio, dan kinestetik.

Kata kunci: Augmented reality, torso, pembelajaran mandiri

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INTRODUCTION

The acceleration of digital technology makes the education system face the challenge of facilitating effective and inclusive learning for learners with different learning needs and styles (Erbas & Demirer, 2019). Technology has opened up new educational opportunities, but the implementation has often been under optimized (Sweller, 2020). Learning facilities centered on conventional methods have only sometimes met the needs of learners with visual, audio, and kinesthetic (VAK) learning styles. A research problem related to the student learning process has been the differences in learning styles between one student and the others (Hadiyanto et al., 2021). Each individual has unique learning preferences, such as visual, audio, and kinesthetic (VAK) learning styles (Solihah et al., 2020). When learning activities do not consider individual student learning styles, this can hinder students' optimal understanding and achievement (Haryono, 2018).

The issue of coordination system materials affecting students' independent learning often relates to the complexity of concepts and the difficulty in providing effective visualization (Susanto et al., 2024). The coordination system is often challenging for students to learn due to its complex concepts involving multiple organs and biological processes interacting within the human body (Pan et al., 2021). A deep understanding of the mechanisms involving the nervous system, muscles, and various receptors requires clear and concrete visualization, which traditional teaching methods may not effectively provide (Yapici & Karakoyun, 2021). Augmented Reality (AR) offers an effective solution for this learning challenge by providing interactive 3D visualizations that allow students to see and understand the structures and functions of the coordination system in detail (Iqbal et al., 2022; Nahri et al., 2024; Safitiri et al., 2024). AR also incorporates audio elements that can verbally explain processes and kinesthetic features that let students interact with virtual models, manipulate objects, and observe the effects of various biological processes in real-time.

The use of technology, specifically Augmented Reality (AR), can offer solutions by presenting interactive and easily understandable three-dimensional visualizations (Damopolii et al., 2022; López-Belmonte et al., 2023). The diversity in students' learning styles presents a challenge in providing appropriate educational media for delivering the material. Each student has different learning style preferences. Some may effectively process and understand information through pictures, diagrams, and visualization, which is categorized as a visual learning style (Fitria, 2023). At the same time, other students would be more responsive to information delivered verbally through lectures or audio recordings, categorized as an audio learning style. Then, some students prefer to learn through physical experience and hands-on practice, which is classified as a kinesthetic learning style (Wiradarma et al., 2023). When the learning methods are not considered individual student learning styles, students with inappropriate learning styles may need help with the subject material.

Conventional learning methods have dominated educational settings (Rijal et al., 2021). These methods focus on transferring information from teacher to student through explaining, reading, or writing assignments (Mahanal et al., 2019). While this method can be effective for some students, students with different learning styles may benefit less. Students with kinesthetic learning styles need hands-on and contextualized experiences to understand the concepts being taught (Gusmaweti & Hendri, 2021). When learning methods do not facilitate learning styles, students tend to disengage and lose interest in learning. Students tend to have independent learning with their learning style if the learning process at school needs to be facilitated more.

Independent learning facilities that align with students' learning styles still need to be expanded (Firdausy et al., 2019). Independent learning is the student's ability to learn independently, manage time, access learning resources, and choose learning methods that suit their learning style (Yunaini et al., 2022). The lack of resources, technology, and accessibility hinders students' ability to learn independently. Students with different learning styles may need help finding learning materials that suit their preferences, thus hindering the development of their learning independence (Matamay et al., 2023). The importance of independent learning cannot be overstated, as it empowers students to take control of their education, develop critical thinking and problem-solving skills, and become more self-reliant and confident (Arifin et al., 2021). Without the ability to learn independently, students may become overly dependent on teachers, struggle with time management, and experience increased stress and anxiety, which can negatively impact their academic performance and personal growth.

Providing independent learning facilities to facilitate all learning styles can be a solution. The development of the augmented reality sensory torso as an edtech-based learning media can be an effective solution (Setiawan et al., 2022). Utilizing AR and edtech technology, learning media can be designed to meet the needs and preferences of individual student learning styles (Firdaus et al., 2022). This will increase students' engagement, understanding of the material, and learning independence. The utilization of Augmented Reality (AR) technology and Educational Technology (Edtech) can be an innovative solution in providing more interactive learning media and adapting to VAK learning styles. Edtech includes the utilization of information and communication technology in an educational context. Edtech can consist of various online learning applications, e-learning platforms and interactive media (Izza et al., 2022). Previous research has shown that using edtech in learning can improve accessibility, flexibility and effectiveness of learning. Edtech can also help learners develop essential digital skills in today's digital era (Rodriguez, 2013).

AR technology enables the integration of visual and audio information in a physical environment, while Edtech facilitates the teaching and learning process through technology specifically designed for educational purposes (Aditama et al., 2021). The development of augmented reality sensory torso as Edtech-based learning media can be an independent learning facility that helps learners master the material with their learning style better. Previous research has shown that using AR in learning can increase learner motivation, understanding, and engagement (Khan et al., 2019). This study aimed to evaluate the effectiveness of this learning media in improving learning achievement and information retention in enhancing innovative self-directed learning by focusing on visual, audio, and kinesthetic learning styles. Using this media can enable students to develop their skills.

METHOD

Research design

The Lee and Owen method consists of analysis, design, development and implementation, and evaluation stages (Lee & Owens, 2004). The analysis stage was essential to understanding the learning context, student needs, and learning style characteristics. This research can determine the dominant learning style for each participant through surveys, observations, and assessments of visual, audio, and kinesthetic preferences. The design stage contained the design of materials and media related to the structure, content, and features of augmented reality sensory torso media designed by considering compatibility with visual, audio, and kinesthetic learning styles. It was designed to use augmented reality technology to make the learning experience exciting and interactive. Considering various student characteristics, this design created an inclusive learning environment and addressed differences in student learning preferences. The stages of development are broken down into pre-production, production, post-production, and quality review. Pre-production stage consists of creating storyboards and organizing materials. The production stage contained visual, audio, and kinesthetic content created for each learning style. Integrating augmented reality technology into the learning content made the concept of understanding more deep and enjoyable. In the post-production and quality review stages, testing is conducted to identify bugs and make corrections before a small-scale trial is carried out. The evaluation stage was used to evaluate the results of product effectiveness and become the basis for improvement. In addition, the evaluate stage involved media testing and material and media validation to ensure optimal quality, functionality, and responsiveness.

Population and samples

Product trials are carried out through quasi-experimental research. This stage includes small group trials and field trials (Cohen et al., 2018). The research was conducted at one of the state schools in Malang City. In the small group, 9 students were used as subjects, with 3 students having a tendency to learn visual style, 3 students audio, and 3 students kinesthetic. We use the small class exclusively to test the effectiveness of the media. Meanwhile, the field trial research involved 64 students, divided into 32 students in the control class. Four data were excluded from the analysis, leaving only 60 data points to be analyzed divided into 9 visual learning styles, 12 audio learning styles, and 9 kinesthetic learning styles. 32 students in the experimental class with 8 visual learning styles, 11 audio learning styles, and 11 kinesthetic learning styles. The implementation time is October 2023, and it will be carried out directly with subjects in class XI.

Instrument

The research employed observation sheets, pretest and posttest questions, student response sheets, and validation sheets for media experts, materials, and learning devices to establish media validity. The media validation sheet assesses text readability, design, visual appeal, color proportion, 3D modeling quality, educational content completeness, interactivity, ease of use, 3D modeling interaction, audio-visual compatibility, installation ease, and smartphone compatibility. The material validation sheet evaluates alignment with objectives and competencies, content completeness and depth, conceptual and visual accuracy, currency, and the ability to stimulate curiosity. The learning tools validation sheet examines syllabus format, completeness, clarity and alignment of indicators, time allocation, and learning syntax. It emphasizes active student participation, student-centered learning, teacher facilitation, technological integration, and fostering independent learning.

Procedure

This study was conducted through a series of structured stages. In the initial stage, preliminary research and needs analysis were conducted to determine the needs of the field. The development step in the Lee & Owens framework is presented in Figure 1. The analysis stage consisted of needs analysis and front-end analysis. The study was conducted on students, teachers, and school curriculum. The design stage consisted of learning material design and media design. The development stage consisted of developing AR torso scanning applications, trials, material validation, and media validation for material experts, media experts, and biology practitioners. The results of valid learning media will be tested on 64 students who studied coordination system material.

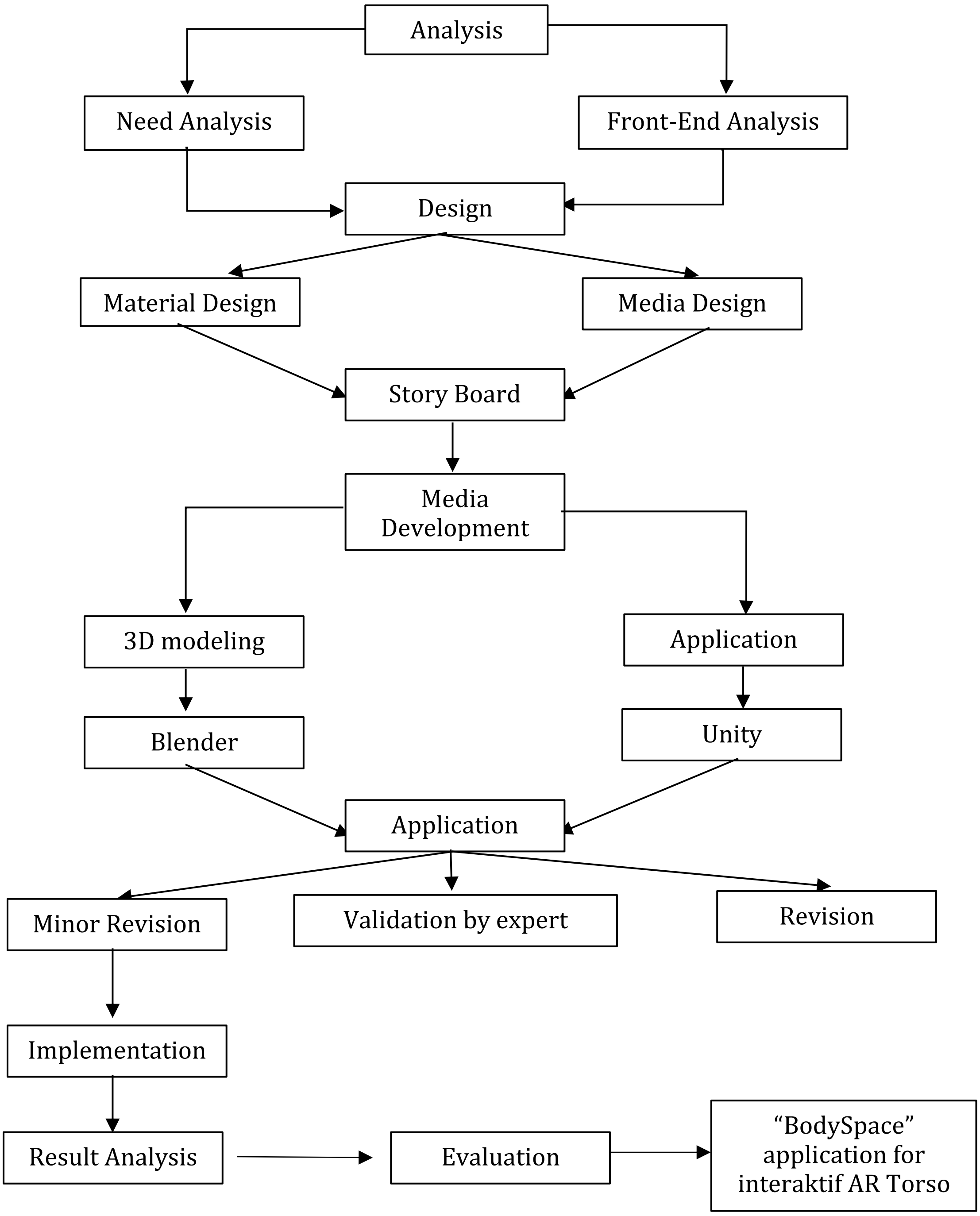

Fig 1. Lee and owens framework

Data analysis techniques

The validation data analysis technique from experts used the product development validation criteria. The data was analyzed using a presentation formula, the results of which were in the form of numbers measured on a Likert scale.

$$P = \frac{\sum x}{\sum xi} \times 100 \quad (1)$$

Description:
P : Percentage
$\sum X$: Total score in the question item
$\sum Xi$: Maximum score in the question item

The Likert scale can measure attitudes, opinions, and perceptions of a person in a group about social phenomena (Sugiyono, 2016). The validation results consist of a scale of 1-5. Number 5 indicated very good criteria, number 4 indicated good criteria, number 3 indicated medium criteria, number 2 indicated poor criteria, and number 1 indicated very poor criteria. After the percentage had been obtained using the available formula, the percentage was used to determine the level of validity of the media and material. The determination of the percentage size of media validation is in Table 1.

Table 1. Qualification criteria for validation results

No.	Percentage	Level validity
1	76% - 100%	Strongly valid, can be used and needs to be reviewed
2	51% - 75%	Valid, usable but needs revision
3	26% - 50%	Insufficiently valid, recommended not to be used because it requires revision
4	1% - 25%	Invalid, not allowed to use, needs a lot of revisions

Source: Adaptation of Wiratna (2015)

Quantitative analysis was carried out through pre-test and post-test to evaluate the significance of changes in students' cognitive achievements before and after using learning media. Learning using augmented reality media was carried out three times and the posttest average was taken for each session.

RESULTS AND DISCUSSION

This research used the Lee and Owens model, composed of five stages: analysis, design, development, implementation, and evaluation. Media use requires scan and marker applications. The application can be used offline. This application included 3D modeling of human sense material. Consists of five senses, including ears, eyes, nose, tongue, and skin. Each purpose has a zoom-in feature to see the tissues and cells in each sense and a voice-over feature that facilitates users with auditory types. The 3D modeling presented can be activated and played like a torso.

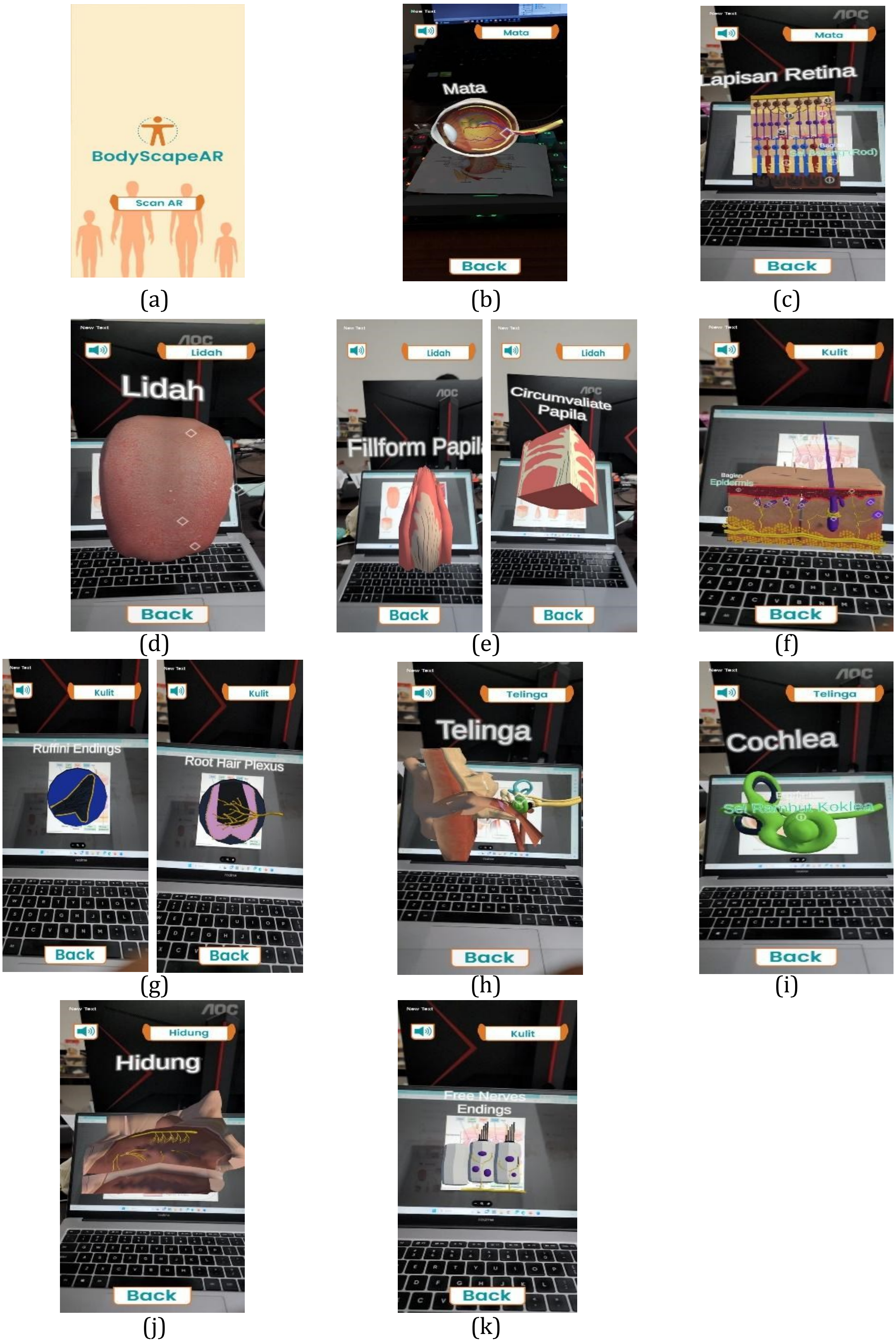

Fig 2. (a) Splash screen, (b) 3D modeling of the eye, (c) 3D modeling of the retinal mesh, (d) 3D modeling of the tongue, (e) 3D modeling of the tongue scent cells, (f) 3D modeling of the skin, (g) 3D modeling of the nerve cells, (h) 3D modeling of the ear, (i) 3D modeling of the inner ear, (j) 3D modeling of the nose, (k) 3D modeling of the nose scent cells.

The results of validation by experts

The validation results were obtained from media experts, materials, practitioners, and learning devices conducted by lecturers who are experts in their fields.

Table 2. The results of media validation

Aspect	Percentage (%)	Validity Level
Design and display	100	Strongly valid
Programming	97	Strongly valid

Table 3. The result of material validation

Aspect	Percentage (%)	Validity Level
Alignment of Material with Objectives, Core Competencies, and Basic Competencies	100	Strongly valid
Accuracy of Material	100	Strongly valid

Table 4. The results of learning device validation

Aspect	Percentage (%)	Validity Level
Syllabus format	100	Strongly valid
Component	100	Strongly valid
Principles of syllabus development	100	Strongly valid

Augmented Reality Sensory Torso learning media based on Table 2, regarding the results of media validation by experts, showed a high level of validity that was very valid. The design and program of AR media are considered very good in their development and ready to be implemented. AR sensory torso media is developed to improve students' independent learning. Therefore, this media must be developed clearly to create an interactive experience that allows users to interact directly with learning materials. According to Musril et al. (2020), this can increase student engagement and allow them to explore concepts more in-depth.

Developing interactive multimedia for students must be concerned with several aspects or components. According to Yadav and Chakraborty (2023), interactive multimedia has several features, including images (still visuals), video (motion visuals), text, graphics, animation, audio (sound) and interactivity. Students can see, hear, and even feel the learning material directly, which allows for a more memorable learning experience. Learning media can help students with various learning styles more easily understand complex concepts and improve information retention, making it an innovative and effective tool in modern education (Azis et al., 2022). The biology field has visual representations in various forms, such as photos, illustrations, tables, graphs, diagrams, and the like (Mulyani, 2017). AR technology to present visual representations in 3D format can positively impact students' understanding of abstract concepts. By using 3D visualization through AR media, the method of delivering material becomes simpler, increasing the effectiveness of teacher explanations and facilitating students' understanding of the material.

Material expert validation described the arrangement of material with objectives, core competencies, and essential competencies, as well as the accuracy of the material in the AR sensory torso. Material validation must achieve a 100% score because the content must be accurate and align with what is taught to students to prevent misconceptions. According to Surata et al. (2020), paying attention to precision when creating learning media must match the material's type and nature. This represents a critical factor in achieving efficiency in the learning process, and it should also consider the needs of students. Not all types of media are suitable for every material in biology, as this largely depends on the characteristics of the material. Learning media allows students to learn more independently, do review exercises after assessment, and enhance their understanding with a more in-depth exploration of the material studied (Abdulrahaman et al., 2020).

The material used in this media is the sensory torso in the material coordination system in biology. According to Qudsiah (2021), material about the coordination system, especially the sensory system, is often considered difficult because it involves understanding how the human body interacts with its environment through different senses. The sensory system includes various organs such as the eyes, ears, nose, tongue and skin, and the complexity of how they detect, process and respond to external stimuli. Each sense has a unique structure and function, and students need to understand how each works and how they contribute to the overall coordination of the body.

Experts conduct validation of learning devices as a form of testing whether the learning process can be implemented and interrelated between the media and devices contained in them. According to Astuti et al. (2019), the activities in the learning device help students understand the material studied through learning steps designed to produce a product that can be useful for achieving learning objectives. Learning tools include syllabi, lesson plans, worksheets, and media. The components in the learning device are adjusted to the model and the skills that the teacher wants to develop; the skills taken in this study are students' independent learning skills.

According to Rajabi et al. (2015), learning tools have valid criteria if the learning tools reflect the consistency between the parts of the learning tools that are compiled and the suitability between learning objectives, learning materials and assessments to be given. This valid device can be given to students to understand the material.

The results of student practicability

Table 5 present the results of student responses regarding three aspects: Ease of Utilize, Languages, and Attractiveness. Each aspect is accompanied by a percentage score reflecting student satisfaction, with scores of 95% for Ease of Utilize and 100% for both Languages and Attractiveness. The overall average percentage for all aspects is 98.3%. All aspects are deemed "Very Practical" indicating a high level of confidence in the results gathered from the student feedback.

Table 5. The results of student response by small group

Aspect	Percentage (%)	Validity Level
Ease of utilize	95	very practical
Languages	100	very practical
Attractiveness	100	very practical
Average all aspects	98.3	very practical

Based on student response data in Table 5, it can be concluded that the AR sensory torso learning media developed by researchers can be used with good feasibility criteria and get positive showed a score of 98.3% in the level of student response. In this case, researchers must also pay attention to the suggestions and comments given by students so that the learning media developed can be even better.

The development of augmented reality sensory torso media with the Visual, Audio, and Kinesthetic (VAK) Learning Styles approach has opened up significant opportunities to improve independent learning at various levels of education. Firstly, this media allows students to learn in a way that corresponds to their learning style. Students more responsive to visual information can explore materials with rich images and videos. According to Margareta et al. (2012), those who learn through hearing will benefit from the audio elements in this media. At the same time, students who learn through physical movement will find an advantage in the kinesthetic component provided by AR technology.

AR sensory torso media can be flexible in learning by students, as it accumulates all three learning styles. It enables learning outside the classroom. Students can access information and learning experiences wherever they are. which allows more flexible self-directed learning. They can check materials at any time and explore concepts with a depth previously challenging to achieve. With the increasing use of AR technology in education, self-directed learning becomes more possible and rewarding, helping students develop lifelong learning skills (Weng et al., 2020).

Self-learning has become increasingly urgent for students today as the digital age and dynamic educational changes demand independence in the learning process. As expressed by Gupta et al. (2021), in a rapidly changing educational environment, students need to have the ability to manage time, seek resources, and learn independently. Independence in learning allows students to develop their critical thinking, problem-resolution, and problem-solving skills. In addition, with the development of technology and easy access to information through the Internet, students now have more opportunities to learn independently. The ability to learn independently helps them overcome learning challenges and prepare themselves for success in the future, where independent knowledge and skills are becoming increasingly important in the world of work and personal life. Overall, the results showed that the AR media sensory torso VAK approach development in learning coordination system material for class XI MIPA students at SMAN in Malang City was very practical.

The result of effectiveness on independent learning

Knowledge assessment was conducted through effectiveness testing using a quasi-experimental design, with experimental and control classes to evaluate the effectiveness of the media on independent learning. Data collected included pretest and posttest of cognitive learning outcome. Prior to further testing, normality and homogeneity tests were performed as prerequisite analyses. The normality test results showed sig. 0.2 for the control class pretest, sig. 0.2 for the control class posttest, sig. 0.07 for the experimental class pretest, and sig. 0.16 for the experimental class posttest. The significance values for each data point are $p > 0.05$. There are no data points outside the normal and extreme ranges. The homogeneity test results yielded a sig. value of 0.128, indicating that the data is homogeneous and can be used for further testing.

Table 6. Independent t-test for pretest

	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Pretest	3.572	0.064	0.11	58	0.909	0.3

Based on the results of the independent t-test for the pretest scores in Table 6, it was found that there is no significant difference between the two pretest cognitive learning data sets, as indicated by Sig. (2-tailed) > 0.05. Consequently, the control class and the experimental class are deemed equivalent and suitable for use as samples. Subsequent hypothesis testing can be conducted on the posttest results for both classes.

Table 7. Independent t-test for posttest

	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Posttest	1.305	0.258	-7.930	58	0.000	-11.8

Table 7 presents the results of the independent t-test used to assess the difference in posttest means between the control and experimental classes. The results indicate a significant difference in posttest means, with a significance level (2-tailed) of 0.000, which is less than the 0.05 threshold. The mean scores for the control class and the experimental class are 78.7 and 90.5, respectively. These findings suggest that students instructed using augmented reality media achieved a higher average learning outcome compared to those in the control class.

The effectiveness test was conducted using two classes, consisting of an experimental class and a control class, which had previously undergone normality and homogeneity tests. The results indicated that both the control and experimental classes were considered equivalent and suitable for further testing. The independent t-test indicate that there is a significant difference in the average scores between the two classes. As shown in Table 7, this means that students taught using augmented reality media achieved a higher average learning outcome compared to students in the control class. The media used in the control class directs students in learning activities according to their respective senses. Students can experience interactive and immersive learning conditions. Learning media development is significant in creating an exciting learning environment and positively impacts student learning outcomes (Buliali & Andriyani, 2021).

AR sensory torso media with the VAK approach has been considered suitable for improving students' independent learning. This result can be seen from the approach used in accompanying media development. The VAK approach in the form of three-dimensional visualization provided by AR provides a deeper understanding of abstract concepts, while the auditory element can strengthen understanding through audio description. With the kinesthetic component. students can be truly involved in learning by performing physical tasks integrated into AR. In line with the results of research by (Nunaki et al., 2019), they mentioned that learning with the VAK method will further strengthen students' understanding of the material, and learning is done by stimulating students to be active and responsive to the concepts provided.

Visualization using augmented reality (AR) on sensory system material is essential because it can provide visual representations that allow students to see and interact with the structure and relationships between sensory systems in detail and clearly. With the help of AR, students can see various components of the sensory system, ranging from organ parts to tissues that exist in the senses, facilitating their understanding of the concept of the coordination system. Taufiq et al. (2022), showed that using AR as a learning tool helps students deepen their knowledge of material that is considered problematic. The context of objects or props discussed or studied can be simulated and shown in three-dimensional form with the help of animations that can be accessed through smartphones, which are currently standard devices (Abdinejad et al., 2021). This allows learners to interact with the objects in the application directly. However, the research encountered challenges such as limited material, focusing only on the coordination system, and inadequate student devices. Therefore, it is necessary to develop augmented reality media on different topics and conduct tests on a wider variety of devices to avoid bugs in the media.

CONCLUSION

The results showed that the developed media is considered valid, practical, and effective in supporting biology education with the help of visual, auditory, and kinesthetic learning styles. Media validation reached 98.5%, material and learning tools validation reached 100%, practicality by students reached 98.3%, and effectiveness was confirmed using the t-test with significant differences in posttest scores, it needs development by applying augmented reality torso media to other material that is relevant in biology learning for students. The research results concluded that learning media is practical and can be one of the media choices for biology learning with visual, audio, and kinesthetic learning styles.

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