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Design and Development of NeuroAR Media on the Nervous System Topic for High School Biology Learning

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Abstract

Biology learning, especially on the topic of the nervous system, presents challenges due to its abstract and complex nature. This study aims to design and develop (validate the feasibility) of Augmented Reality (AR)-based media, called NeuroAR, to support the learning of nervous system concepts. The type of research used is research and development (R&D), with research steps referring to the 4D Models, which include the stages of Define, Design, Development, and Dissemination. This study was limited to the Development stage because it focused solely on developing and validating the feasibility of NeuroAR without including the Dissemination stage. A needs analysis was conducted through curriculum review, student difficulties, and expert interviews. The product was developed using SolidWorks, Blender, Unity3D, and Assemblr Edu, and produces AR media accessible via a mobile app. The feasibility of the media was assessed by two experts who are media and material experts using structured instruments and student readability tests in a small group. The product (AR Markers) was integrated into student worksheets, allowing interactive experiences through NeuroAR media. The result of this research is the product of NeuroAR media on the nervous system topic that has been declared feasible and valid for use in learning, as indicated by the results of material and media expert validations categorized as very valid and the readability tests by students, which showed a positive response.

Keywords: augmented reality, development of media learning, nervous system in senior high school material.

INTRODUCTION

Biology learning involves both concrete and abstract concepts. Abstract topics, such as those in the nervous system, are often difficult for students to grasp because they cannot be directly observed. This makes it challenging for students to visualize the bioprocesses occurring within the body's organs, leading to difficulties in understanding the content (Putri et al., 2020; Bababola et al., 2021; Micallef & Newton, 2024).

Learning biology, particularly in the context of the nervous system, can be challenging for students due to the high level of complexity of the material, which often makes it difficult to comprehend (Telaumbanua et al., 2024). Microscopic structures such as neurons and synapses, as well as physiological processes such as the mechanism of nerve impulse transmission, are difficult for students to visualize clearly, thus potentially hindering their understanding of the material. Learning the nervous system topic requires deep understanding, as it involves studying the structure and function of neurons, the mechanism of nerve impulse transmission, and the interaction between the central and peripheral nervous systems (Lewar & Suhartini, 2023).

Azizah et al.' (2021) study states that students experience difficulties in learning the topic of body systems. This is supported by the research results of Snapir et al. (2017), which state that abstract concepts that are part of a process in the human body are difficult for students to imagine and think

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about clearly, because they cannot be directly seen. Research by Rohmah & Anggraito (2021) mentions that exam scores on the topic of the coordination system fall into the low category. The topic is too complex and abstract for students, and students feel that the coordination system material is difficult to understand, especially in the subtopic of the nervous system. Interactive learning media are needed to help visualize abstract and complex concepts so that they are easier to understand and remain in students' memories longer (Agustini et al., 2024). Learning media can serve to clarify, simplify, and make the material that the teacher will deliver to students more interesting, so that it can motivate learning and facilitate the learning process (Siregar & Kurniawati, 2022).

Overcoming learning challenges in science, particularly in biology, requires the effective use of digital technologies. These technologies offer various benefits, including improving learning quality and enhancing students' interest in specific subject matter (Kartini et al., 2023). One persistent difficulty in science education is understanding abstract and complex concepts that cannot be directly observed (Sudiana et al., 2025). Recently, Augmented Reality (AR) has been integrated into the educational field as an innovative instructional medium. AR demonstrates strong potential for supporting scientific concept acquisition by visualizing scientific phenomena and enriching the learning experience (Ma et al., 2025). This technology enables the presentation of three-dimensional (3D) virtual objects that interact with the real environment in real-time, creating a more immersive and interactive learning atmosphere. Through mobile applications, AR media can present engaging educational content that captures students' attention. It is accessible anytime, anywhere, and is easy to use (Cai et al., 2021; Ciloglu & Ustun, 2023).

The application of AR technology in the learning process can enhance student participation and support the improvement of learning quality (Singhal et al., 2012). Students can observe three-dimensional (3D) representations of human body organs such as the brain, nerves, and neurons, as well as see how physiological processes in the nervous system work in a more tangible and interactive manner. Previous studies have shown that this kind of visualization helps improve concept retention, reduce cognitive load, and facilitate deeper understanding (Demircioglu et al., 2023; Vardar-ulu et al., 2024). Moreover, AR's interactivity enhances student engagement, motivation, and learning outcomes (Chen et al., 2017; Mattola et al., 2021; Limbong et al., 2023).

In addition, AR media contributes to improving students' self-efficacy in learning biology. Self-efficacy, which refers to an individual's belief in their ability to complete specific tasks, is one of the key determinants of academic success. A study conducted by Ciloglu & Ustun (2023) demonstrated that the use of AR media in biology learning is significantly more effective in enhancing students' self-efficacy compared to conventional learning methods. This improvement makes students more confident, active, and ready to face various academic challenges.

The application of AR in biology education has been shown to support the development of students' mental models, particularly on abstract topics such as the nervous system. Interactive visualizations help students connect new knowledge with prior understanding, making complex processes more accessible and reinforcing conceptual learning (Siregar & Kurniawati, 2022). The development of AR media has been carried out to improve students' understanding of the nervous system material. Research conducted by Rohmah & Anggraito (2021) confirms that AR media developed with expert validation is suitable for improving students' comprehension of the nervous system.

In response to these findings, this study presents the development of an AR-based learning media called NeuroAR. This media features interactive 3D animations, including a dynamic visualization

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of the impulse transmission mechanism, which is an innovative learning tool for explaining abstract and complex concepts. The development followed a structured process consisting of the Define, Design, and Development stages, including expert review and readability testing to ensure the media's effectiveness and feasibility in learning.

RESEARCH METHOD

This research is a research and development (R&D) using a 4D model that includes the Define, Design, Development, and Dissemination stages. However, the Dissemination stage was not carried out because this study was limited until the Development stage to focus on producing a feasible and well-validated AR media before classroom implementation.

Research Objectives

This study aims to develop NeuroAR media for the nervous system topic for 11th-grade students and to evaluate the feasibility of the developed media through expert validations (material and media experts) and student readability tests.

Development Stages

To illustrate the systematic process of developing the NeuroAR media, the following flowchart presents the main stages of the development process, which consist of the Define, Design, and Develop phases. This chart outlines the key activities carried out in each phase as part of the adapted development model:

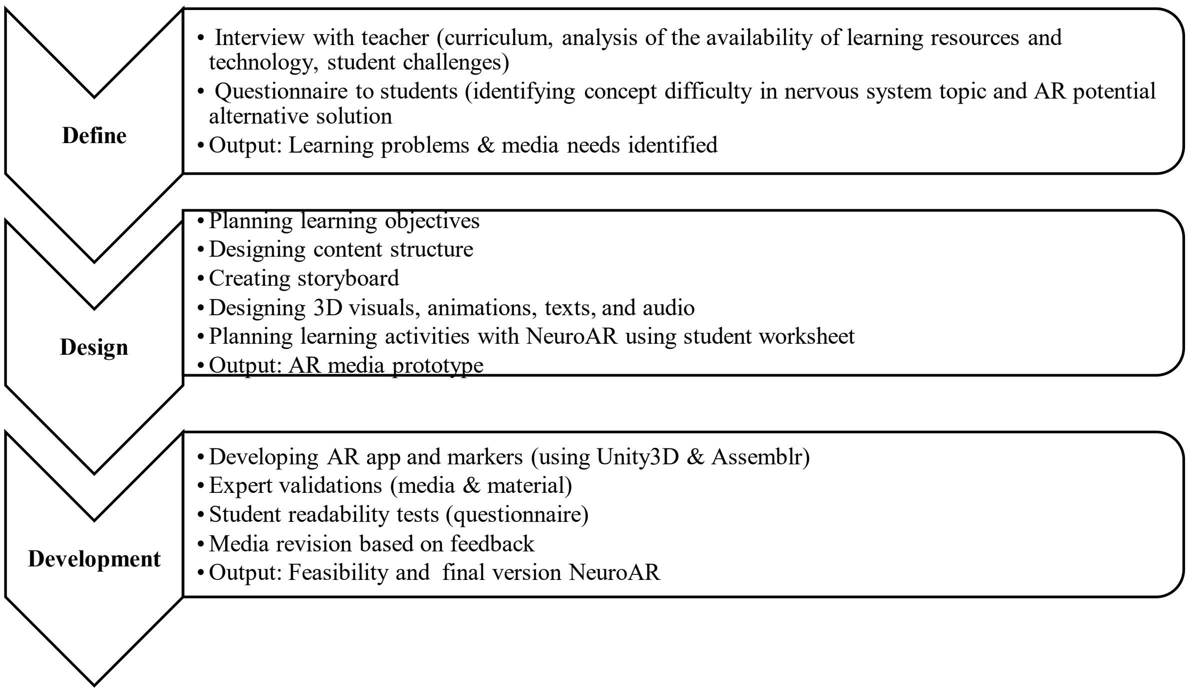

Figure 1. Flowchart for developing the NeuroAR media.

1. The **Define stage** began with a needs analysis to identify students' learning challenges, assess the availability of learning resources and technology, and determine which materials—particularly abstract concepts related to the nervous system—were difficult to understand. Questionnaires were distributed to students to gather information on their learning difficulties

and to explore the potential of augmented reality (AR) as a possible solution. The results from this stage formed the basis for the planning and design of the learning media.

2. The **design stage** focused on learning the planning content of NeuroAR media. Activities included creating a storyboard, designing visualizations of nervous system concepts in the form of 3D organs, 3D animations of bioprocesses, explanatory texts, and labeling of structural parts. Additionally, audio elements such as explanatory narration and sound effects were designed, along with interactions and animations to clarify abstract concepts. This stage also included the design of learning activities that support student engagement while using NeuroAR.
3. In the **Development stage**, AR content was developed using Assemblr Edu, Unity 3D, SolidWorks, Blender, and Sketchfab, incorporating markers and mobile application access. Development of instruments for validations by media expert and material expert, development of student response instruments in a limited trial conducted with a small number of students. The subjects in the limited trial consisted of 33 11th-grade students, who were surveyed using a questionnaire. Subsequently, revisions to the NeuroAR media were made based on suggestions and feedback from experts and the results of the limited trial. Expert validation results were used to determine the feasibility of the product, so that the developed AR media could be declared feasible or not for implementation.

Instrument

The instruments used in this study included expert validation sheets (media and material expert), student readability tests (questionnaires), and interview protocols for biology teachers.

Data Analysis Techniques

The data collected were analyzed using qualitative and quantitative methods. Qualitative data consisted of feedback, comments, and suggestions from experts and teacher interviews, which were used for media revision and improvement. Quantitative data were obtained from expert validations, readability tests, and analyzed using descriptive statistics in the form of percentage calculations. This formula was used to determine the percentage from the validation results:

$$\text{Percentage (\%)} = \frac{\text{Score obtained}}{\text{maximum possible score}} x\ 100\%$$

The results of the validity of each expert (material and media), as well as the combined analysis results that have been obtained, can be adjusted or confirmed with the established validity criteria, which were adapted from research by Riduwan (2015).

Table 1. Interpretation Criteria for Media Expert Validation Results

Percentage (%)	Category
81-100	Very Valid
61-80	Valid
41-60	Quite Valid
21-40	Not Valid
0-20	Invalid

Source: Riduwan (2015)

Meanwhile, the results of the student readability tests were categorized according to the criteria guidelines established by Sugiyono (2010).

Table 2. Results of Readability Tests by Student

Percentage (%)	Category
81-100	Very Good
61-80	Good
41-60	Good Enough
21-40	Not Good
0-20	Very Not Good

Source: Sugiyono, (2010)

RESULT AND DISCUSSION

Research Result

This section presents an explanation based on the three stages of the research and development process: analysis, design, and development phases. Each phase is systematically described to illustrate the process of developing NeuroAR media for the nervous system material.

The results of the **analysis phase** identified several shortcomings, including a lack of innovation and limited use of instructional media, as well as students' difficulties in understanding certain concepts related to the nervous system. The learning process had not yet leveraged technology effectively as a teaching medium.

Based on the results of a questionnaire distributed to students, the majority reported difficulties in studying biology, particularly in nervous system topics involving bioprocess concepts. This was attributed to the abundance of complex terminology and the limited clarity of teachers' explanations, which were inadequately supported by clear visuals or videos. Additionally, it was found that nearly all students already owned smartphones, which could potentially be utilized in the learning process.

Interviews with the biology subject teacher revealed that current instructional practices remained predominantly teacher-centered, resulting in passive student engagement. Learning outcomes on the nervous system topic showed that only 29.41% of students met the minimum mastery criteria. Students experienced significant challenges in understanding complex concepts such as impulse transmission along axons and across synapses, mechanisms of voluntary and reflex actions, and the structure and function of the brain and spinal cord. AR technology had never been used due to limited time and teacher expertise. Learning relied mainly on textbooks and PowerPoint presentations.

The **Design stage** of AR media development involved planning the learning process, defining objectives, and selecting content delivery strategies for the nervous system topic. The media was designed based on student characteristics and the identified need to visualize abstract concepts. The AR media integrated various components such as narrative text, images, 3D objects, animations, and videos to encourage interactive and meaningful learning. The content developed includes the structure and function of nerve cells, types of nerve cells, impulse conduction (along axons and across synapses), the brain and spinal cord, and voluntary and reflex movements. These were adapted from credible sources, including *Campbell Biology* and Grade XI high school textbooks. A storyboard was created to outline the flow of AR displays, user interaction sequences, and multimedia elements such as labels and narration. The development tools used were SolidWorks, Sketchfab, Canva, Unity3D, and Assemblr Edu. Blender was employed to create 3D models using its graphical user interface. The output of the design process included AR storyboards for each subtopic, interactivity schemes, draft visuals and 3D assets, and AR marker designs to be embedded in the Student Worksheet (LKPD) for

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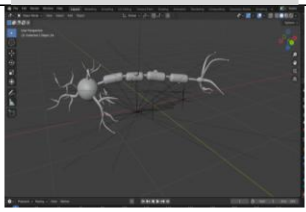
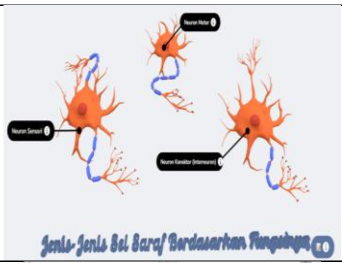
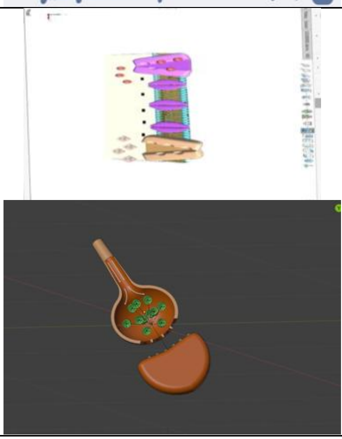
classroom implementation. Table 3 is a storyboard developed in the AR media design stage for the nervous system.

The AR media developed in this study not only covers the structure of nerve cells but also includes the types of nerve cells, the impulse conduction mechanism (featuring dynamic 3D animations), the structure and function of the central nervous system, and the mechanisms of voluntary and reflex movements. This broader scope represents a novelty in the application of AR technology for teaching abstract and complex biological concepts, such as those found in the topic of the nervous system.

Table 3. Storyboard of AR Media Design for The Nervous System

Visual	Description
	Content description: learning objectives and learning outcomes, six nervous system concepts Interaction: tap the learning objectives, learning outcomes, and menu.
	Content description: contains information on the structure of nerve cells and the function of each part. Interaction: pop up (tap) to find out the function of each part, rotate in any direction, zoom in, and zoom out.
	Content description: contains material information on the types of nerve cell structures based on their functions, along with the functions of the types of nerve cells. Interaction: pop up (tap) to find out the function of each form of nerve cell, rotate in any direction, zoom in, and zoom out.
	Content description: contains information on the impulse transmission mechanism. Interaction: tap to find out the stages of the impulse transmission mechanism, navigate to zoom in, zoom out, rotate, and get a description of each stage.

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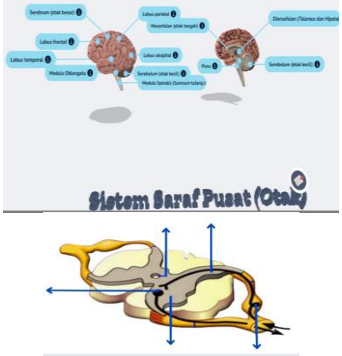
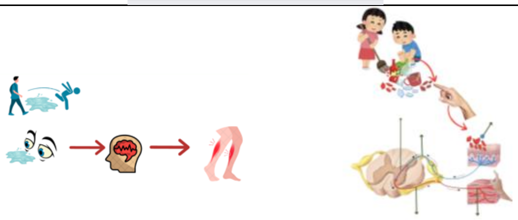
Visual	Description
	Content description: contains material information on the structure and function of the central nervous system Interaction: pop up (tap) to know the function of each part of the brain and spinal cord, rotate in all directions, zoom in, and zoom out.
	Content description: contains information on the mechanism of conscious movement and reflex movement. Interaction: scene button to bring up the mechanism of reflex motion, pop up (tap) to find out the stages of conscious and reflex motion mechanisms, rotate in all directions, zoom in, and zoom out.

Subsequently, the **development stage** is a continuation of the design stage, focusing on implementing the design into a usable Augmented Reality (AR) learning media product. The media was developed by integrating visual assets such as three-dimensional (3D) objects, animations, supporting 3D images, and narrative text into an AR-based platform. The development was carried out using the Assemblr Edu and Unity3D software. The 3D objects used in the AR media were created using SolidWorks and Blender, as well as the Sketchfab web platform. Materials related to the structure and function of nerve cells, types of nerve cells, the central nervous system, and the mechanisms of voluntary and reflex movements can be accessed via Assemblr World (compatible with all device types). Meanwhile, the content for the impulse transmission mechanism can be accessed via “AR Sistem Saraf” application (Android users only), which was developed separately using SolidWorks, Blender, and Unity3D to provide a dynamic visualization of Na+ and K+ ion pumps during the processes of polarization, depolarization, repolarization, and impulse transmission between neurons via synapses.

This stage also involved expert validation (media and material) and a student readability limited test. The next process is expert validations carried out by competent experts in their fields to test the feasibility of the product. A total of two material and media experts were involved in this stage. The interpretation criteria for media and material expert validation results were adapted from research by Riduwan (2015). Recapitulation of media and material expert validation results is shown in Table 4 and 5.

Table 4. Media Expert Feasibility Results

Aspect	**Score (%)**	
	V1	**V2**
Visual Display	100	95
Usability	100	100
Language usage	100	100
Average validity score	**98,3% (Very Valid)**	

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Table 5. Material Expert Feasibility Results

Aspect	Score (%)	
	V1	V2
Completeness of content	100	100
Suitability of material content	100	93
Instructional	100	100
Average validity score	**97,6% (Very Valid)**	

Based on Table 4, the validation results from media experts indicate that the developed AR media has an excellent quality, achieving an average feasibility score of 98.3%, categorized as highly valid. The evaluation covered visual design, AR functionality, and language use. The aspects of AR utilization and language use each received full scores from both validators. Based on Table 5, material expert validation results indicate a high level of validity across three aspects: content completeness, content feasibility, and instructional quality, with an average feasibility score of 97.6%. The content completeness and instructional validity were rated as very valid, as they aligned with learning outcomes and objectives. Both media and material expert validations confirm the AR media's feasibility for instructional use, requiring only minor revisions. Recommendations included standardizing pop-up backgrounds, adding content references, including a welcome marker with user guidance, and formatting explanations using numbered lists. These suggestions and feedback have been implemented through revisions.

Before implementation, a student readability test was conducted to ensure the media matched learners' abilities. Feedback from students was used to refine the media. Table 6 below presents the recapitulation of the readability test results obtained through a questionnaire. Student Readability Assessment Categories are based on Sugiyono (2010).

Table 6. Results of Readability Test by Students

Aspect	Value	Category
Content	85,40%	Very Good
Media Display	94,13%	Very Good
Software	82,40%	Very Good
Linguistic	85,40%	Very Good
Average	**86,83%**	**Very Good**

Based on Table 6, the readability test results indicated that student responses were generally categorized as “very good” across all aspects. However, several technical issues were noted, such as incompatibility with certain mobile devices, delays in displaying AR content after scanning markers, and occasional disappearance of content when the marker was not properly aligned with the camera. The content aspect was also rated “very good”, indicating that the information was clear and systematically presented. These results suggest that the NeuroAR media was well-received and considered feasible for use in classroom settings. Figure 2 and Figure 3 show NeuroAR media displaying nervous system content after marker scanning.

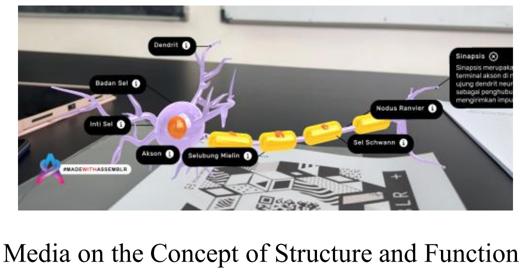

Figure 2. AR Media on the Concept of Structure and Function of Nerve Cells

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Figure 3. AR Media on the Concept of Axon-Length Impulse Transmission Mechanism

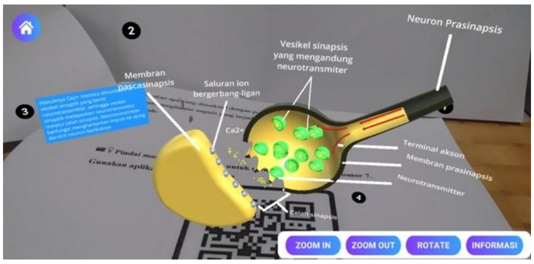

Figure 4. AR Media on the Concept of Impulse Transmission Mechanism between Synapses

The media display aspect achieved the highest results (94,13%), indicating that students considered the visual presentation clear, attractive, easy to understand, interactive, and helpful in understanding abstract and complex topics. Therefore, the NeuroAR media was well-received in terms of usability and visual clarity. These findings suggest that good design can be a key factor in enhancing students' initial interest in the subject matter being studied. While this study did not evaluate learning outcomes, previous research has emphasized the potential of AR to enhance engagement and reduce cognitive load (Aldeeb et al., 2024; Cheng & Tsai, 2013; Wu et al., 2013). These insights support the relevance of NeuroAR media in educational learning. However, further research is recommended to evaluate its effectiveness in improving students' conceptual understanding and self-efficacy.

The software aspect showed the lowest score among all, although it was still categorized as "very good." This was due to several students encountering difficulties downloading the application, either because their devices did not support the installation or because they had insufficient memory storage. In the digital era, the ability to use digital learning technologies has become an essential competency. AR media leverages digital devices such as smartphones, tablets, or computers to access and display technology-based learning content. Despite these challenges, the integration of AR media through mobile devices reflects the increasing relevance of digital learning tools in education. Although this study did not specifically measure digital literacy, the use of AR-based media may support students' familiarity with technology.

Research Discussion

The analysis results emphasize the urgent need for more innovative instructional strategies. Students' difficulty in grasping abstract concepts such as nerve impulses is consistent with Kadarusman et al. (2020), who stated that imagining the processes occurring in nerve cells is particularly difficult, preventing students from relating the content to real-life contexts. The student responses in the questionnaire also highlighted their desire for technology-based learning media with clear visuals or videos, which could be reviewed repeatedly and include step-by-step explanations. These needs suggest that interactive digital media—particularly those utilizing Augmented Reality (AR)—can

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provide the kind of object visualization necessary to enhance student motivation and understanding. Furthermore, the fact that most students already have smartphones presents a significant opportunity to implement mobile-based AR learning solutions. These findings justify the need to develop engaging and interactive AR media that could support better conceptual understanding and foster active learning environments in biology education.

The challenges identified in the Define stage—such as students' difficulty in visualizing nerve impulses and understanding bioprocesses—were used as a direct foundation for content planning in the Design stage. These difficulties reflect students' struggle with abstract biological processes that are not directly observable, which aligns with earlier findings in biology education. Therefore, the AR content was deliberately structured to provide visualization, starting from basic structural animations to dynamic simulations of impulse transmission, ensuring gradual conceptual scaffolding. The readability test results, which indicated that students found the NeuroAR media clear, engaging, and helpful, confirm that this design approach effectively addressed their learning barriers. This also suggests that integrating visual and interactive elements into complex topics can enhance cognitive accessibility and reduce students' learning anxiety, supporting the media's potential for broader implementation. This aligns with cognitive load theory, which posits that well-designed visuals can reduce extraneous load and facilitate information processing, especially when dealing with abstract and dynamic scientific content. By engaging multiple sensory modalities, students are more likely to retain information and feel more confident in their learning. Therefore, such integration not only supports individual learning outcomes but also offers scalability for broader classroom implementation. According to research findings, Özçakır & Aydın (2019), Augmented Reality technology can increase active participation by introducing new technology into the classroom and attracting students' attention. In line with the research results of Putri et al. (2020), Augmented Reality has good visualization that can build broader and more complete interpretations for students, thereby helping them understand abstract concepts. These results suggest that the developed NeuroAR media effectively addresses the identified learning needs, although its effectiveness in improving learning outcomes has yet to be fully tested. Validation by media and content experts indicated that the product was highly valid in terms of visual appearance, ease of use, language use, and content relevance to the curriculum.

The integration of various multimodal components—such as 3D visualizations and animations—was essential for helping students form accurate mental models and reduce cognitive load when learning complex topics (Mayer, 2005). The use of AR platforms embedded with 3D modeling tools has been shown to enhance students' spatial reasoning and conceptual understanding in biology (Cai et al., 2021; Tang et al., 2020). Dynamic visualizations of such physiological processes can enhance comprehension by enabling learners to interact with representations that are otherwise unobservable (Arici et al., 2019). AR markers are embedded in the Student Worksheet (LKPD) to facilitate the learning process and make it more effective, as Rahma et al. (2024) mention that the use of AR-based LKPD is effective in adapting to 21st-century learning.

The media expert validation results confirmed the high quality of the AR media. The visual aspect was deemed highly valid. Based on the results of previous studies, effective color use has been found to enhance student interest (Rohmah & Anggraito, 2021). However, the visual display received a score of 95% from the second validator due to several minor visual inconsistencies noted in the initial version of the AR media. These included the need for standardization of the pop-up backgrounds across different subtopics, adjustments to text placement to avoid overlapping with 3D models, and suggestions for improving the contrast between labels and the background to enhance readability.

The Consequences, although these issues did not significantly hinder usability, they affected the overall visual harmony and user experience. The validator noted that improving these aspects could help reduce potential distractions and support a clearer focus on the learning content. Improvement efforts, following the feedback, revisions were made to standardize the design of pop-up backgrounds to ensure visual consistency, adjust label positions and font size for better readability, and enhance color contrast in certain scenes to improve visual clarity. These changes were implemented in the final version of the NeuroAR media, which was then retested in the student readability trial, where the visual display category received a very high score (94.13%), indicating successful improvements. Ease of use was also rated highly valid, based on the simplicity of installation, functionality of interactive buttons (e.g., rotate, zoom, information), and overall user-friendliness. Based on previous research findings, the language used was clear, appropriate for students, and adhered to standard Indonesian language rules. Proper language use facilitates comprehension and fosters appreciation for national languages (Wulandari & Muhroji, 2025).

The feasibility of the material expert was also declared very valid due to its adherence to curriculum standards, scientific accuracy, and relevance to student needs, with materials sourced from Campbell Biology and other credible textbooks. Based on previous research findings, Dhani et al. (2023) mention that those who emphasize the importance of curriculum alignment and quality references for effective learning. One of the material validators gave a score of 93% for the suitability of the material content aspect. This slightly lower score was due to the absence of specific references for several concept explanations and a lack of clarity in the alignment between certain content and the learning objectives. The consequence of this finding is the potential for reduced coherence between the presented materials and the curriculum framework. As a follow-up, content revisions were made by adding clear references, ensuring that all subtopics align explicitly with the competencies and indicators stated in the curriculum. The instructional aspect (student comprehensibility) was also rated very valid because the material presentation was organized in a simple, systematic manner and adapted to students' cognitive development levels, thereby facilitating comprehensive understanding. Based on previous research findings, Robasto et al. (2022) mention that the instructional aspect helps students to fully understand the material in accordance with their way of thinking, making learning easier to follow and more engaging.

The highest-rated aspect was media display (94.13%), suggesting strong student appreciation for its clarity and interactivity. These results suggest that design quality has a significant impact on student interest. While this study did not directly assess learning outcomes, prior research supports AR's ability to boost engagement and lower cognitive load (Aldeeb et al., 2024; Cheng & Tsai, 2013; Wu et al., 2013). Although the software aspect scored lowest, it still received a "very good" rating. Challenges included device incompatibility and memory limitations.

Nevertheless, AR media integration promotes digital literacy—an essential 21st-century competency. Previous research by Nevrelova et al. (2024) has shown that AR integration has the potential to foster digital literacy and support active, motivated, and collaborative learning environments. The linguistic aspect showed a very good result, indicating that the language used in the NeuroAR media adheres to proper Indonesian language conventions in accordance with the General Guidelines for Indonesian Spelling (PUEBI) and is easily understood by students. The final product developed at the end of this development stage is a NeuroAR media on the nervous system topic, which was then integrated into the Student Worksheet (LKPD) with markers that can be scanned to display the AR content. In previous research, Wulandari & Muhroji (2025) stated that the proper use of the Indonesian language according to the General Guidelines for Indonesian Spelling (PUEBI) is an effort to increase student engagement in learning and foster a love for their national language.

CONCLUSION

Although full implementation in the classroom has not yet been conducted in this study, expert validation of the content and media indicates that NeuroAR falls into the highly valid category, and readability tests by students also show positive responses. Thus, after undergoing several development stages, the NeuroAR media was declared feasible and ready for use in the context of high school Biology learning. The developed NeuroAR media features a novel 3D animation of the concept of impulse transmission mechanisms. Further evaluation is recommended to assess its impact on learning outcomes.

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