

Needs Analysis of Interactive 3D Learning Media for Grade VIII Students' Engagement and Understanding of Cell Structure and Function

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ABSTRAK

Penelitian ini bertujuan untuk mendeskripsikan hasil observasi dan diagnosa pembelajaran Biologi di kelas VIII MTs As Shalihin. Penelitian menggunakan pendekatan deskriptif kuantitatif dengan teknik pengumpulan data berupa observasi, wawancara guru, angket siswa. Hasil penelitian menunjukkan bahwa pembelajaran masih didominasi metode ceramah sehingga siswa cenderung pasif dan kesulitan memahami materi biologi khususnya sel yang bersifat abstrak. Keterbatasan media dan fasilitas praktikum juga menjadi hambatan dalam proses pembelajaran. Meskipun perangkat pembelajaran telah sesuai Kurikulum Merdeka, implementasinya belum optimal. Berdasarkan hasil observasi, siswa lebih tertarik pada pembelajaran berbasis praktik dan media visual interaktif. Oleh karena itu, diperlukan inovasi pembelajaran berupa media fisik interaktif (seperti model 3D) dan model pembelajaran aktif untuk meningkatkan pemahaman serta keterlibatan siswa dalam pembelajaran biologi.

ABSTRACT

This study aims to describe the results of observations and diagnoses of Biology learning in grade VIII of MTs As Shalihin. The study used a quantitative descriptive approach with data collection techniques including observation, teacher interviews, student questionnaires. The results showed that learning was still dominated by lecture methods, resulting in students tending to be passive and having difficulty understanding biology material, especially cells, which are abstract. Limited media and practical facilities also hindered the learning process. Although learning tools were in accordance with the Independent Curriculum, their implementation was not optimal. Based on observations, students were more interested in practice-based learning and interactive visual media. Therefore, learning innovations in the form of interactive physical media (such as 3D models) and active learning models were

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Introduction

Education encompasses the process of educating, the body of knowledge concerning education, and the nurturing and training of individuals in their physical, spiritual, and inner lives (Tim Pengembangan Ilmu Pendidikan, 2007). Education is a developmental process that occurs through an individual's interaction with the social and physical environment and continues

throughout life, beginning at birth. It may also be understood as guidance provided to children so that, in the future, they can independently undertake the duties and responsibilities of their lives. Education serves as a means of holistic and harmonious self-development, fostering a balanced personality that encompasses the physical, intellectual, and spiritual dimensions (Effendi, 2022).

Education has a broad scope because it is inherently interwoven with life itself. It unfolds through interactions and mutual influence among individuals and can therefore take place anywhere and at any time, without being confined to a particular period. The aims of education are aligned with the aims of life: to guide people towards holistic development, including material and spiritual well-being, physical and mental health, and the full development of personality (Rasyidin et al., 2023). Under Law No. 20 of 2003, education also aims to develop learners' potential so that they acquire spiritual capacities, intelligence, good character, and skills that benefit themselves, society, the nation, and the state (President of the Republic of Indonesia, 2003).

Learning is a dynamic and complex process through which individuals seek to understand and acquire new knowledge and skills that they have not previously mastered. It can occur at any time and in any setting, whether in formal environments such as schools and universities or in everyday life beyond formal education (Putri et al., 2024). Learning engagement refers to learners' active involvement—physical, emotional, and intellectual—in the learning process. It extends beyond physical movement to include sensory responses and cognitive activity. Thus, learners who appear physically still may nonetheless be actively engaged when they are listening and thinking. The form and degree of engagement vary among individuals and tend to shift from predominantly physical activity in childhood towards more non-physical forms of engagement as individuals mature (Gunawan, 2019).

Biology includes abstract concepts and phenomena that require direct observation to help students understand them. This is consistent with Agustina et al. (2020), who noted that some biology topics, including cells, inheritance, and photosynthesis, are abstract and difficult for students to understand. Cell biology is particularly abstract because it concerns the structure and functions of prokaryotic and eukaryotic cells, including macromolecules, membranes, and organelles that are microscopic and cannot be observed directly (Mutmainna et al., 2025). As a result, students often find it difficult to understand the forms and components of cells. Learning media that can visually represent prokaryotic and eukaryotic cells are therefore needed to make the topic more accessible to students.

Classroom observations in Grade VIII at MTs As Shalihin showed that instruction remained teacher-centred and relied on lecturing, with limited interaction and students who were often passive and less focused. Interviews with the science teacher identified limited facilities as a key constraint, including insufficient LCD projectors and a ban on mobile phone use, which restricted the use of visual media. Students were also not accustomed to active learning and remained

dependent on teacher explanations. To address these issues, instruction could be enhanced through interactive physical media, such as three-dimensional models, simple teaching aids, and independent projects, alongside the use of Problem-Based Learning or Project-Based Learning. These approaches are expected to increase student engagement, deepen conceptual understanding, and help students connect biology content with everyday life.

Methodology

This study employed a qualitative descriptive approach with a case study design to analyse the need for developing interactive three-dimensional (3D) physical learning media to support student engagement and understanding of cell structure and function. It also aimed to describe biology teaching and learning conditions and identify instructional challenges and needs in Grade VIII at MTs As Shalihin. The study was conducted in April 2026 at MTs As Shalihin in Makassar. Participants comprised one science teacher and 19 Grade VIII students from a single class. The teacher held a bachelor's degree in Biology Education, had more than five years of teaching experience, and had implemented the Merdeka Curriculum. The students were aged 13–14, had not previously used 3D learning media to study cell structure and function, and represented a range of academic abilities. Participants were selected through purposive sampling. The inclusion criteria were that the teacher taught science to Grade VIII students in the 2025/2026 academic year and that the students were actively enrolled in Grade VIII and had parental consent. MTs As Shalihin was selected because 3D learning media for cell biology were not available, student engagement appeared to be low, and the school supported research and the introduction of instructional innovations. Teaching on cell structure and function was primarily lecture-based and relied on two-dimensional illustrations in textbooks, indicating the need to identify whether more interactive and concrete media were required. Given the qualitative descriptive design, the study did not test causal effects; instead, it documented learning needs and classroom conditions as a basis for developing learning media.

Data were collected through observation, interviews, a questionnaire, and document analysis. Three structured, non-participant observations were conducted, each lasting two 40-minute periods, to examine classroom instruction, student engagement, and the use of teaching methods, models, and media. Observations were recorded using an observation form and supplemented with documentation. A semi-structured interview lasting approximately 30–45 minutes was conducted with the science teacher using an expert-validated interview guide. The interview was recorded and transcribed to gather information about instructional challenges, strategies, and needs. Students completed a closed-ended questionnaire using a five-point Likert scale over approximately 15–20 minutes to assess their interests, learning experiences, and

responses to biology instruction. The questionnaire was tested for validity and reliability, with a Cronbach's alpha criterion of > 0.70 . Questionnaire data were analysed descriptively by calculating scores and percentages. Document analysis was also conducted on the teaching module, student worksheets (LKPD), learning media, and assessment instruments to examine their alignment with the principles of the Merdeka Curriculum. A checklist was used, and its results were reviewed with a validator. The research instruments comprised an observation form, an interview guide, a student questionnaire, and a document-analysis form. Data were analysed descriptively through data reduction, data display, and conclusion drawing. The findings were used to identify the main challenges in biology instruction and determine instructional innovations suited to the school context and students' characteristics.

The unit of analysis was the biology teaching and learning process in the classroom, including teacher activities, student activities, the use of instructional materials, and student responses. Data from the four sources were analysed qualitatively and descriptively in three stages: data reduction, data display, and conclusion drawing. During data reduction, raw data from observations, interview transcripts, questionnaire responses, and document-analysis notes were selected and grouped according to the research indicators. For data display, findings from all four sources were presented in descriptive narratives and cross-tabulations to facilitate comparison. The sources were integrated through source triangulation, which involved comparing and synthesising classroom observations, the teacher interview, student questionnaire responses, and the alignment of instructional documents to develop a comprehensive and credible account of the learning challenges. Conclusions were then drawn from patterns and themes that emerged consistently across the four data sources. The analysis was used to identify the main challenges in biology instruction and determine instructional innovations appropriate to the school context and students' characteristics. The study was conducted after written permission had been obtained from the school and consent had been secured from the science teacher and participating students.

Results and Discussion

This study was conducted through classroom observations, interviews, and the distribution of questionnaires to Grade VIII students at MTs As Shalihin. The findings revealed that the biology learning process still faced several challenges that affected students' engagement and conceptual understanding during learning activities.

Classroom Observation Findings

Direct classroom observations were conducted to examine the teaching and learning of biology, specifically the nervous system. The findings are presented in Table 1.

Table 1

Classroom Observatons Findings for Biology Lessons in Grade VIII at MTs As Shaliin

No	Aspect Observed	Observation Mark	Description of Findings
1	Lesson opening (prior knowledge activation and motivation)	✓	The lesson began routinely, led by the class leader, with greetings and a prayer. The teacher then proceeded directly to the topic without activating students' prior knowledge by linking previous and new material or providing motivation to engage their interest.
2	Communication of learning objectives	✓	The teacher briefly named the topic before writing it on the board but did not explain what students were expected to learn or the benefits of mastering the material by the end of the lesson.
3	Student engagement in learning	✗	Most students sat listening and taking notes. When the teacher posed questions, the class tended to fall silent; students appeared passive and did not respond to the explanation.
4	Time management and lesson flow	✗	Time was not allocated effectively. The lesson followed a monotonous, teacher-centred sequence, with the teacher spending most of the class period delivering a lecture. As a result, the final part of the lesson was rushed.
5	Teacher–student and student–student interaction	✗	Communication was predominantly one-way, from the teacher to the students, with little student feedback. Group discussions were rarely observed, making the learning process appear largely individual.
6	Student responses to biology content	✗	Students showed signs of boredom as they mainly received and copied theoretical content without connections to everyday life that might have encouraged their interest and responses.
7	Classroom management (environment and order)	✗	The classroom was not conducive to learning. Some students engaged in off-task activities, such as daydreaming, doodling, or whispering to classmates. The teacher had difficulty maintaining students' focus, which appeared to be associated with their low psychological engagement.
8	Lesson closure and reflection	✗	The lesson ended when the bell rang, without a summary. The teacher did not review students' understanding of the lesson, as the classroom conditions made it difficult to do so.
9	Indicators of an engaging lesson	✗	Students' enthusiasm and activity were directed towards off-task behaviour, such as

No	Aspect Observed	Observation Mark	Description of Findings
	(student enthusiasm, participation, and understanding)		socialising, rather than towards understanding the lesson content.
10	Learning difficulties (confusion, passivity, and lack of engagement)	✓	Students appeared confused and showed little interest, which was associated with the prolonged use of lecture-based instruction without variation. Consequently, they became passive and seemed unsure how to begin engaging with the material.

The classroom observation findings in Table 1 indicate that biology instruction remains conventional and strongly teacher-centred. Harahap and Albina (2025) similarly note that one-way lecturing can limit students' physical and psychological engagement. This pattern was evident from the start of the lesson: the teacher neither activated students' prior knowledge nor provided motivation, leaving them unclear about the relevance of the topic and its connection to everyday life. Consequently, the classroom was passive, students remained silent when asked questions, and some appeared bored or engaged in off-task activities, such as daydreaming or whispering to classmates. These observations are consistent with Zahrotun Nisa et al. (2025), who argue that activating prior knowledge helps students understand new material and encourages their participation in learning. When teachers connect a lesson to students' existing knowledge or experiences, students may feel more confident and motivated to learn. This process also allows teachers to assess students' understanding of previous content and adjust their teaching strategies accordingly.



Figure 1. Classroom Observation Documentation

This situation is compounded by ineffective time management, as the lesson period is largely taken up by monotonous explanations. Wahidaty (2021) observes that an unstructured lesson

sequence can prevent teachers from evaluating learning, facilitating reflection, or summarising key points at the end of a session because the lesson is interrupted by the bell signalling the next class. Yet reflection-in-action involves teachers' ability to respond appropriately to dilemmas as they arise in the classroom and to address students' learning needs in the moment. More broadly, reflection includes evaluating both positive and negative events that occur during the teaching and learning process (Wahyuni, 2020).

Overall, the lessons lacked meaningful moments of engagement, as students' enthusiasm was directed towards activities unrelated to the subject matter. Siagian et al. (2025) argue that without varied teaching methods and efforts to establish two-way interaction, instruction may fail to engage students' potential or provide meaningful understanding. Dai (2024) likewise notes that positive teacher–student relationships can benefit teachers' professional development and students' learning outcomes. Such relationships can help students regulate their emotions, participate more actively in class, strengthen their learning skills, and pursue academic achievement and goals. In this role, teachers can listen attentively to students' emotional needs, guide the learning process, and support creative thinking.

Teachers Interview Findings

An interview was conducted with the biology teacher to explore the teacher's perspectives on instructional media, learning models and methods, and challenges in teaching. A summary of the interview findings is presented in Table 2.

Table 2
Teacher Interview Findings for Grade VIII at MTs As Shalihin

No	Question	Summary of Response
1	Which biology topics do students find most difficult to understand?	Cell structure and the relationship between structure and bodily function are generally the most challenging topics because they are microscopic and abstract. Students cannot see cells with the naked eye and therefore often memorise organelle names without fully understanding how these small structures work together to support the functions of the body as a whole.
2	How do you support students who have difficulty understanding abstract concepts?	I usually use teaching aids, animated videos, or simple analogies drawn from everyday life. For example, I compare a cell to a “factory” in which each organelle has a specific role.
3	What challenges do you most often encounter when teaching biology?	The main challenges are differences in students' learning pace, limited instructional media, and restricted lesson time. Students' motivation can also decline when the material involves extensive memorisation, causing many of them to lose focus.

No	Question	Summary of Response
4	Which strategies have successfully improved students' understanding?	I have tried more interactive approaches, such as Project-Based Learning, and connected the material to everyday life. These approaches have improved understanding among some students. However, not all students are ready for active learning: some are accustomed to receiving information directly from the teacher and find it difficult to analyse problems independently.
5	What is one aspect of biology teaching in the classroom that you would like to change?	I would like to create more opportunities for practical work and direct exploration while ensuring that instruction remains aligned with the applicable curriculum and educational guidelines. This would help students see science, particularly biology, as a subject grounded in real life and relevant to their own experiences, rather than simply as a subject that requires memorisation.

As shown in Table 2, the teacher identified cell structure as an especially abstract and microscopic topic that students find difficult to understand. To address this difficulty, the teacher has simplified the concepts through the “factory” analogy, in which each organelle has a specific role, and has used animated videos as visual aids. This use of analogy is consistent with Sapari et al. (2017), who argue that learning occurs when students connect new information with relevant concepts already present in their cognitive structures. The strategy is intended to move students beyond memorising organelle names towards a functional understanding of how these small structures work together to support bodily functions.



Figure 2. Documentation of the Teacher Interview

The main challenges are the lack of learning media that can realistically visualise microscopic objects and the limited time available for lessons. The teacher noted that content requiring extensive memorisation often reduces students' motivation and causes them to lose focus in class. This relates to Vygotsky's constructivist theory, which emphasises scaffolding—providing support in stages to help learners move from guided understanding towards independent understanding (Tamrin et al., 2011). The challenge is compounded by students' reliance on teacher-provided explanations, which makes it difficult for them to analyse problems independently when asked to engage in active approaches such as Project-Based Learning.

These limitations in learning resources and student readiness directly affect the implementation of the exploratory strategies the teacher hopes to use. The teacher expressed a strong desire to make biology lessons more practice-based and exploratory, so that students can experience the subject as relevant to real life. This is consistent with Mardhani et al. (2025), who report that inadequate facilities and infrastructure can substantially affect the effectiveness of the teaching and learning process.

Student Questionnaire Results

The student questionnaire was administered to capture students' perspectives on their experiences of learning biology. It used a five-point Likert scale, ranging from Strongly Agree (SA) to Strongly Disagree (SD). The results are presented in Table 3.

Table 3
Student Questionnaire Results

No	Statement	SA	A	Somewhat Disagree	D	SD	Most Frequent Response
1	I enjoy biology lessons in class.	58%	42%	0%	0%	0%	Strongly Agree
2	I understand the teacher's explanations of biology content.	63%	26%	11%	0%	0%	Strongly Agree
3	I actively ask and answer questions during biology lessons.	42%	42%	16%	0%	0%	Agree
4	I can relate biology content to everyday life.	44%	44%	11%	0%	0%	Agree
5	The media or teaching aids used by the teacher help me learn biology.	63%	37%	0%	0%	0%	Strongly Agree
6	The learning model or approach used by the teacher makes me active.	63%	37%	0%	0%	0%	Strongly Agree
7	I have enough time to	58%	32%	10%	0%	0%	Strongly Agree

No	Statement	SA	A	Somewhat Disagree	D	SD	Most Frequent Response
8	understand each topic. The teacher's way of teaching biology makes me want to learn more.	67%	33%	0%	0%	0%	Strongly Agree
Note: SA = Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree.							

The questionnaire results show that students generally responded positively to biology instruction. All students (100%) agreed or strongly agreed that they enjoyed biology lessons, with 58% strongly agreeing. Intrinsic motivation also appeared strong: the statement about wanting to learn more because of the teacher's approach (Statement 8) received the highest proportion of "Strongly Agree" responses, at 67%. This finding is consistent with Ravelina et al. (2023), who suggest that teachers' instructional approaches can generate substantial initial interest among students.

However, some aspects indicate room for improvement, particularly active classroom interaction. The largest proportion of "Somewhat Disagree" responses concerned students' participation in asking and answering questions (Statement 3; 16%), followed by their ability to relate biology content to everyday life (Statement 4; 11%). Thus, although students enjoy the lessons, not all of them participate actively in verbal exchanges or consistently connect the content to real-life contexts. As Setyawati (2024) notes, effective learning depends in part on students' ability to connect abstract concepts with concrete, real-world contexts appropriate to their cognitive development.



Figure 3. Documentation of Student Questionnaire Administration

Questionnaire and interview data showed that most students were enthusiastic about biology. Cell biology was the most popular topic, selected by 16 students, who considered it both challenging and understandable. However, students still reported difficulty with abstract concepts

in topics such as the circulatory and digestive systems and the differences between animal and plant cells. They attributed these difficulties to complex processes and unfamiliar terminology. These findings are consistent with the questionnaire results: 16% of students reported that they were not very active in asking questions, while eight students wanted explanations to use simpler, more familiar language.

Students also expressed a strong preference for learning through direct experience rather than relying solely on theoretical explanations. Twelve students identified practical activities as the most enjoyable and effective way to learn biology without becoming bored, and another eight hoped that practical work would be offered more frequently. Although most students found visual media, such as LCD projectors and Smart TVs, helpful for visualising content, the absence of hands-on activities still left some students confused. Safitri et al. (2025) similarly emphasise the importance of innovative, interactive, and concrete learning media in bridging visual explanations and practical understanding, attracting students' attention, and supporting their active engagement with complex biological concepts.

Students responded positively to the media and teaching approaches currently used: 63% strongly agreed that these resources helped them participate actively. Nevertheless, interactive 3D physical learning media may offer further support for understanding abstract concepts, particularly cell structure and function. Such media could provide opportunities for hands-on exploration, help address students' remaining uncertainty about their participation, and clarify differences among organelles that students find difficult to distinguish. This expectation is consistent with Setyawati (2024), who highlights the value of exploratory, tangible learning activities. Interactive 3D physical media may therefore enable students to engage more fully and develop a deeper understanding of cell structure. Sawitri et al. (2024) also report that innovative media can attract students' attention, sustain their interest in learning, and improve their conceptual understanding.

Conclusion

Biology instruction at MTs As Shalihin continues to face a major challenge: the predominance of one-way lecturing, which limits student engagement. Although the teaching module incorporates innovative lesson plans, classroom practice remains conventional and teacher-centred. As a result, two-way interaction is rare, and students' attention is often diverted to non-academic activities, such as daydreaming or chatting, when lessons are delivered without engaging variation in teaching methods.

Students' difficulties in understanding the material stem largely from the abstract and microscopic nature of cell structure and function. They tend to memorise organelle terminology without developing a thorough understanding of how organelles function. Limited school facilities,

including the small number of LCD projectors and the prohibition on mobile phone use, further constrain teachers' ability to present the material digitally. Consequently, instruction tends to revert to text-based memorisation, which may not adequately support students' cognitive development.

The needs analysis revealed strong student interest in more concrete learning experiences through practical activities or teaching aids. Students need media that they can handle and manipulate to make abstract concepts more tangible. Developing interactive three-dimensional (3D) physical learning media is therefore a pressing response to the need to support student engagement and conceptual understanding. Such media may help students view biology as a subject connected to real life rather than merely one that requires memorisation.

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