

OPTIMIZATION OF BIOLOGY LEARNING MEDIA IN IMPROVING LEARNING EFFECTIVENESS BASED ON STUDENTS' LEARNING STYLES

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ABSTRAK

Penelitian ini bertujuan untuk menganalisis optimalisasi media pembelajaran Biologi untuk meningkatkan efektivitas belajar berdasarkan gaya belajar siswa. Penelitian dilakukan di MAN 1 Medan pada bulan September 2025 dengan satu guru Biologi sebagai responden utama, yang dipilih karena aktif menggunakan berbagai media pembelajaran dan menyesuaikan strategi mengajar dengan karakteristik siswa. Data dikumpulkan melalui kuesioner tertutup dan wawancara semi-terstruktur untuk menggali jenis, efektivitas, dan kesesuaian media pembelajaran dengan gaya belajar visual, auditori, dan kinestetik siswa. Hasil penelitian menunjukkan bahwa guru telah menerapkan berbagai media, termasuk media visual, digital, dan alat praktikum untuk meningkatkan pemahaman konsep. Media visual dan kegiatan praktikum ditemukan sebagai yang paling efektif, dengan tingkat kesepakatan masing-masing 95% dan 90%, sementara keterbatasan infrastruktur dan kompetensi digital guru masih menjadi tantangan utama. Penelitian ini menekankan bahwa optimalisasi media pembelajaran membutuhkan fasilitas yang memadai, keterampilan teknologi, dan kesadaran akan keberagaman gaya belajar. Pemilihan media yang selaras dengan gaya belajar siswa dapat meningkatkan motivasi, keterlibatan, dan hasil belajar, sehingga mendukung pengembangan strategi pembelajaran Biologi yang adaptif dan berpusat pada siswa.

Kata Kunci: Pembelajaran Biologi, media pembelajaran, gaya belajar, efektivitas, pembelajaran digital

ABSTRACT

This study aims to analyze the optimization of Biology learning media to improve learning effectiveness based on students' learning styles. The research was conducted at MAN 1 Medan in September 2025 with one Biology teacher as the main respondent, chosen because of active use of various instructional media and adaptation of teaching strategies to student characteristics. Data were collected through a closed-ended questionnaire and semi-structured interviews to explore the types, effectiveness, and compatibility of learning media with students' visual, auditory, and kinesthetic styles. The findings show that teachers have implemented various media, including visual, digital, and practical tools, to enhance conceptual understanding. Visual media and practicum activities were found most effective, with agreement levels of 95% and 90%, respectively, while limited infrastructure and teachers' digital competence remain key challenges. The study highlights that optimizing learning media requires adequate facilities, technological skills, and awareness of learning style diversity. Aligning media selection with students' learning styles increases motivation, engagement, and learning outcomes, supporting the development of adaptive and student-centered Biology learning strategies.

Keywords: Biology learning, learning media, learning styles, effectiveness, digital learning

INTRODUCTION

Biology learning is one of the subjects that requires students to understand various scientific concepts that are abstract and complex, making it difficult for some students to comprehend them (Farahani et al., 2023). The Biology learning process does not only emphasize conceptual mastery but also the development of critical, analytical, and creative thinking skills (Santia & Hidayati, 2024). However, in practice, many students

still experience difficulties in understanding Biology material due to the learning process being less engaging and still dominated by conventional methods. One of the main causes of the low learning effectiveness is the suboptimal use of instructional media that align with students' characteristics and the material being taught.

Using audiovisual learning media, such as videos, animations, and interactive multimedia, is a key approach to attract students' interest and help them understand complex biological concepts (Zai et al., 2024). The use of appropriate media can enhance students' motivation, engagement, and learning outcomes (Munawir et al., 2024). However, according to research conducted by Siregar et al., (2025) most teachers still rely on conventional learning methods using simple media such as laptops, projectors, and textbooks, without incorporating more interactive innovations or adjustments to students' characteristics and learning styles. This finding aligns with Susanti et al., (2024) who stated that the lack of alignment between instructional methods or media and the individual characteristics and needs of students can hinder the effectiveness of the learning process, as each learner has a different way and pace of processing information.

However, recent studies in the Indonesian context reveal that the challenges in optimizing instructional media also stem from inadequate digital literacy among students. For example (Ulfah, 2024) found that although students acknowledged the importance of digital media in learning, many still lacked the experience and responsibility required to use digital platforms effectively. This indicates that the issue lies not only in infrastructure but also in students' readiness and competency in utilizing educational media.

Additionally, a study published in *Media Didaktika* showed that differentiated learning requires media to be tailored to the characteristics and learning styles of students in order to promote deeper engagement and better conceptual understanding. (Ana, 2022) emphasized that differentiated media based learning can only be effective when both teachers and students recognize and respond to diverse learning needs. Therefore, this supports the urgency of analyzing how instructional media in Biology can be aligned with students' learning styles to enhance learning outcomes a gap that this study aims to address.

Several previous studies have discussed the importance of selecting appropriate instructional media to improve Biology learning outcomes. For instance, research by Alwi & Agustia, (2024) found that the use of videos in teaching can significantly enhance students' conceptual understanding and information retention compared to conventional lecture-based methods. Nevertheless, this study did not further analyze the influence of students' different learning styles as a factor that may affect the effectiveness of video-based learning. Moreover, a study by Derici & Susanti, (2023) highlighted that teachers tend to use instructional media without first analyzing students' learning style characteristics. This limitation indicates a research gap regarding how the optimization of instructional media can be aligned with students' learning styles to improve the effectiveness of Biology learning.

This research seeks to fill that gap by analyzing how the optimization of Biology learning media can enhance learning effectiveness based on students' learning styles. It also aims to identify the types of instructional media most suitable for visual, auditory, and kinesthetic learners, and to measure the extent to which the alignment between media and learning styles affects students' learning outcomes. Therefore, the results of this study are expected to make a meaningful contribution to the development of Biology learning strategies that are more adaptive, effective, and student-centered.

LITERATURE REVIEW

Theoretical Framework

Learning media play a crucial role as a medium for delivering instructional messages effectively to achieve learning goals. In Biology education, media serve a particularly strategic function since many biological concepts are abstract and difficult to comprehend without visualization or direct experience. The use of instructional tools such as videos, animations, 3D models, and digital laboratory simulations has been shown to help students connect theoretical knowledge with real-world phenomena they encounter in their surroundings. Research by (Rahma, 2024) found that interactive technology-based learning media can enhance student engagement by up to 35% compared to conventional lecture methods. However, the success of media utilization largely depends on the appropriateness of the media type with student characteristics and the teacher's competence in managing them. In practice, many teachers still face obstacles such as limited facilities and inadequate training in the use of digital media

Learning effectiveness essentially reflects how far the learning process achieves its intended goals. According to (Ihwana et al., 2025) effectiveness can be observed from improvements in learning outcomes, motivation, and student participation. In Biology learning, effectiveness can be enhanced through active learning activities such as observation, experimentation, group discussions, and problem-solving. Studies have shown that interactive media not only improve learning outcomes but also foster higher motivation among students. Nevertheless, when media do not align with student characteristics or are not supported by teacher competence, the expected learning outcomes cannot be fully achieved.

In addition to instructional media, students' learning styles are also an essential factor to consider (Surata, 2020) classifies learning styles into three main types: visual, auditory, and kinesthetic. Visual learners grasp concepts better through images, diagrams, and colors; auditory learners prefer verbal explanations or discussions; while kinesthetic learners learn best through hands-on activities such as experiments. In Biology classes, these styles often coexist, requiring teachers to integrate diverse media types to accommodate all learners. Combining visual and kinesthetic media could increase material retention by up to 40%, emphasizing the need to align media selection with learning style variations.

Further research supports the positive correlation between learning styles and the effectiveness of instructional media. (Rofinaa & Mellisa, 2022) found that video-based and simulation media were more effective for visual and kinesthetic learners, whereas auditory learners benefited more from audio-based media or discussions. (Dindardiya & Supardi, 2024) also highlighted that teachers' ability to identify students' learning styles is a critical determinant of successful media selection. Teachers who understand these variations tend to design learning experiences that are more engaging, efficient, and capable of enhancing Biology learning outcomes significantly.

Previous Studies

Several prior studies have emphasized the importance of instructional media and learning styles in determining the effectiveness of Biology learning. (Simamora & Yogica, 2022) examined the implementation of blended learning in Biology and found

that integrating digital media with laboratory practices improved student learning outcomes by 25%. This finding suggests that combining online learning with hands-on activities can enhance students' engagement and comprehension of biological concepts. However, (Rahayuningsih, 2013) noted that the implementation of digital media still faces challenges such as inadequate infrastructure and lack of teacher training, which may hinder its optimal use.

(Aprilia et al., 2022) also demonstrated that selecting media compatible with students' learning styles significantly affects Biology learning outcomes. Visual and kinesthetic learners achieved higher results when using interactive video and virtual laboratory simulations than auditory learners who relied on audio-based media. This finding supports theory that learning styles influence how students process and understand information. Similarly (Rofinaa & Mellisa, 2022) found that combining visual media with direct practice not only improved comprehension but also strengthened long-term memory retention in Biology subjects.

Furthermore, (Rahma, 2024) investigated the effectiveness of virtual laboratory use in Biology learning and discovered that digital laboratories serve as efficient alternatives when fieldwork is not feasible. (Dindardiya & Supardi, 2024) also reported that technology-based interactive media can simultaneously improve student motivation and achievement. Taken together, these findings suggest that the effectiveness of Biology learning depends not only on the type of media used but also on the alignment between media selection, students' learning styles, and teachers' ability to manage instructional resources. (Wibowo et al., 2022)

Therefore, this study seeks to strengthen previous findings through research conducted at MAN 1 Medan, aiming to identify both challenges and solutions in implementing Biology learning media tailored to students' learning styles. The results are expected to contribute to the development of more effective and contextually relevant teaching strategies, as well as encourage teachers to become more adaptive in integrating educational technology optimally.

RESEARCH METHODS

The research focused on a single Biology teacher as the primary respondent. The teacher was selected due to their active use of diverse learning media in the classroom and their experience in adapting teaching methods to students' learning characteristics.

Data collection was carried out using a closed-ended questionnaire and a semi-structured interview. The questionnaire was specifically designed to collect quantitative data on the teacher's perceptions of the types of learning media used, their effectiveness in supporting students' conceptual understanding, and their compatibility with students' learning styles (visual, auditory, and kinesthetic). Additionally, the questionnaire aimed to identify challenges faced during media implementation and to gather suggestions for improvement. Meanwhile, the semi-structured interview was conducted to obtain more in-depth information on how the teacher selected, applied, and evaluated the effectiveness of the learning media in the classroom.

The questionnaire instrument was developed based on several key indicators. These indicators included: (1) the frequency of using visual, digital, printed, and practical media in Biology learning, (2) the perceived effectiveness of each media type in supporting conceptual understanding, (3) teachers' awareness and consideration of students' learning styles (visual, auditory, and kinesthetic) during media selection, and (4) challenges encountered in implementing media. Additionally, the instrument

contained statements designed to assess teachers' readiness and need for training related to learning media development. The semi-structured interview was guided by questions related to teaching strategies, constraints experienced in using media, and innovations implemented by the teacher to optimize learning.

FINDINGS AND DISCUSSION

The analysis of data obtained through the distribution of questionnaires to Biology teachers indicates a positive tendency toward the implementation of various types of learning media in the educational process. Descriptive results show that most respondents agreed or strongly agreed with statements regarding the use of visual, digital, and practical learning media, as well as students' understanding of their learning styles. This condition reflects teachers' efforts to adapt Biology teaching methods to technological advancements and student diversity.

Overall, the data indicate that the integration of technology-based learning media has gradually been implemented, although it has not yet been fully optimized due to limitations in facilities and teachers' digital competencies. Meanwhile, visual media and practical activities remain the most preferred approaches used by teachers in explaining abstract biological concepts.

Table 1. Recapitulation of Biology Teachers' Questionnaire Results on Learning Media and Students' Learning Styles.

Aspect Measured	Percentage of "Agree" + "Strongly Agree" (%)	Brief Interpretation
Use of technology-based learning media (PowerPoint, videos, interactive apps)	80	Teachers have begun implementing digital media, though not optimally.
Availability of supporting facilities (projectors, internet, laboratories)	60	Facilities are still limited and unevenly distributed.
Effectiveness of visual media (images, diagrams, 3D models)	95	Visual media are considered most effective for understanding concepts.
Use of printed media (textbooks, worksheets)	85	Traditional media remain as complementary tools.
Effectiveness of practical activities	90	Practicum activities are effective for kinesthetic learners.
Limitations of facilities as barriers to innovation	75	Main obstacle in media development and innovation.
Students' enthusiasm for video/animation-based media	95	Students show high engagement when using digital media.
Teachers' need for training in educational	90	Professional development in

technology		digital literacy is highly needed.
Effect of interactive media on student engagement	80	Interactive media enhance classroom participation.
Teachers' understanding of different learning styles (visual, auditory, kinesthetic)	88	Teachers acknowledge learning diversity but struggle to apply it individually.

Based on the table, the highest indicators appeared in the aspects of visual media usage (95%), practicum effectiveness (90%), and students' enthusiasm toward video-based media (95%). This indicates that Biology teachers perceive experience-based and visualized learning approaches as the most effective in enhancing conceptual understanding. In contrast, the aspect of facility availability obtained only 60%, signifying that the main obstacle to optimizing learning media still lies in infrastructure and teachers' technological skills.

The results of the study indicate that Biology teachers have implemented various types of learning media, including digital, visual, and practical media. The high percentage of agreement on the use of visual media and practicum activities shows that teachers consider these two approaches to be the most effective methods for improving students' conceptual understanding of Biology. This finding is consistent with previous research reporting that experiment- or practicum-based media strengthen students' science process skills and conceptual understanding (Sari et al., 2024)

Nevertheless, the utilization of technology-based learning media has not yet reached an optimal level. Limitations in infrastructure such as projectors, internet connectivity, and teachers' ability to operate digital media remain major barriers. This aligns with studies emphasizing that the lack of technological facilities and inadequate teacher training are primary obstacles to the implementation of interactive learning media (Sholikah et al., 2025). Thus, even though innovative media have been introduced, their success still depends on institutional support and teachers' professional competence.

From a theoretical perspective, learning-style research emphasizes that instructional effectiveness is not solely determined by the type of media used, but also by the degree to which the media align with students' learning characteristics. Visual learners tend to understand material better through images and animations, while kinesthetic learners are more engaged during practical activities.

Furthermore, this study confirms that the use of interactive digital media positively affects students' motivation and engagement. Teachers who incorporate videos, animations, or online quizzes report increased student participation in Biology classes. This finding is reinforced by studies demonstrating that interactive digital media enhance both motivation and academic achievement compared to conventional methods (Wicaksono & Wiratama, 2024). Therefore, the development of technology-based learning media should continue to be pursued to support active, innovative, and contextual learning processes.

Overall, optimizing Biology learning media depends on three main aspects: the availability of facilities and infrastructure, teachers' competence in managing media, and their ability to adapt media to students' learning styles. These factors are interrelated and collectively determine instructional effectiveness. Without sufficient support and training, even the best learning media cannot produce optimal outcomes.

The findings of this study underscore the importance of experiential and visually-oriented learning strategies in enhancing students' conceptual understanding in Biology.

The dominance of visual media and practicum based activities aligns with constructivist learning theory, which posits that learners build understanding more deeply through direct experience and multimodal representation. This approach is especially valuable in abstract biological topics, where visualization and hands-on engagement foster a more meaningful conceptual grasp.

Nonetheless, persistent infrastructural limitations reveal that many schools struggle to deploy digital learning media effectively. Limited access to projectors, laboratory facilities, reliable internet connectivity, and ongoing technical support remain significant barriers. Without institutional interventions and equitable resource allocation, the potential of interactive media may continue to be underutilized.

Another key factor is teacher competence. While educators recognize the benefits of educational media, many lack the pedagogical and technological skills necessary to design, implement, and integrate digital tools into their teaching. This suggests that professional development should go beyond simple technical training, incorporating both digital literacy and instructional design principles to maximize media effectiveness.

From a learning-styles perspective, the results highlight the need for media differentiation. Though visual and practicum-based approaches scored highest, students have diverse preferences: some benefit more from kinesthetic, auditory, or reflective learning. Thus, multimodal media development should account for these differences, ensuring inclusive and adaptive learning experiences for all.

These findings collectively emphasize the need for systemic and sustainable support to optimize the use of learning media in Biology education. Schools should invest in ongoing professional development, allocate dedicated budgets for media infrastructure, and establish clear evaluation mechanisms to measure the learning impact of media implementation. A coordinated approach among educators, administrators, and policy-makers is essential to ensure that media-based innovations progress from isolated interventions to long-term pedagogical transformation (Ikhsan, 2023)

CONCLUSION

This study concludes that the optimization of Biology learning media can significantly enhance learning effectiveness when aligned with students' diverse learning styles. Visual and practical media are considered the most effective in improving students' conceptual understanding, while the integration of interactive digital media increases motivation and engagement. However, the limited availability of facilities and teachers' digital competence remains a major barrier to maximizing the use of innovative learning media.

The findings contribute to developing more adaptive, student-centered Biology learning strategies that combine technology with hands on experiences. This study suggests that improving teachers' digital literacy and providing adequate infrastructure are crucial steps toward optimizing learning media use. Future research is recommended to involve a larger number of respondents and to analyze the direct impact of specific media types on learning outcomes across different educational levels.

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