

Potential Application of ESD-Oriented Differentiated Learning Website on Biotechnology Materials

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APA Citation: Pribadi, P. A., Nugroho, A. S., & Hayat, M. S. (2026). Potential Application of ESD-Oriented Differentiated Learning Website on Biotechnology Materials. *Quagga: Journal of Education and Biology*, 18(1), 1-11. DOI: 10.25134/quagga.v18i1.466.

Received: 27-05-2025

Accepted: 13-08-2025

Published: 06-01-2026

Abstract: *The demands of 21st century learning require teachers to develop learning media that are not only in accordance with student learning needs but also adapt to the era, one of the relevant media alternatives is the website. The purpose of this study was to analyze the potential application of website-based learning media with a differentiated and ESD-oriented approach to Biotechnology material. The method used in this research is descriptive quantitative, the research subjects are 10 biology teachers in Kebumen Regency and 95 students at SMAN 1 Karanganyar, Kebumen Regency. Data collection techniques through questionnaires for teachers and students and document analysis of teacher teaching modules, then analyzed descriptively based on the average value of each indicator. The scale categories are divided into 0-20% very poor, 21-40% poor, 41-60% fair, 61-80% good, and 81-100% very good. The results of the teacher questionnaire analysis showed that the indicators of teacher understanding of differentiated learning obtained an average of 73% (Good), teacher understanding of ESD 72% (Good), teaching habits of teachers 74% (Good), infrastructure conditions 81% (Very Good), and the potential of the Website 90% (Very Good). The results of the analysis of student questionnaires obtained results for the category of student learning habits average 76.3% (Good), habits of using the website 74.8% (Good), and supporting infrastructure 72.1% (Good). The results of the module analysis show that the implementation of differentiated learning is good but the integration of ESD has not been done explicitly. From the results of the analysis, it can be concluded that the development of ESD-oriented differentiated learning websites has the potential to be applied in learning Biotechnology materials.*

Keywords: *Differentiated Learning Website, ESD-Oriented, Biotechnology*

1. INTRODUCTION

Today's learning is expected to integrate technology to align with the characteristics and needs of the current generation of students. Over the past two decades, following the widespread introduction of the internet, technology has experienced rapid advancements, which have had a significant impact on various aspects of society (Kamal et al., 2019; Putra et al., 2022), especially post-pandemic, reliance on the internet has only gotten stronger. The growth of internet users in Indonesia, which stands at 82 million and ranks 8th globally, underscores the pervasive influence

of the technology. (Waqfin et al., 2023). In digital era education, one of the technology-based learning media that can be an alternative is website. Web-based learning platforms offer flexibility and accessibility, allowing students to learn independently at their own rate without time and space constraints. (Suripah & Susanti, 2022). Research shows that web-based learning media offers several advantages for education. It can integrate a variety of multimedia content, increasing student engagement and understanding. (Layyinnati, 2022; Suripah & Susanti, 2022).

Web-based learning media has been proven effective in improving student participation and learning outcomes. This platform offers flexibility, giving students the option of accessing educational content anytime and anywhere. ([Meduri et al., 2022](#)). The school website serves as one of the main information centers and can support the teaching and learning process. ([Widianto et al., 2024](#)). The website can be utilized to upload learning content, share assignments, and conduct evaluations. ([Ayu et al., 2021](#)). To optimize the benefits of web-based learning, teachers need proper education and training in utilizing this platform effectively. ([Ayu et al., 2021](#); [Widianto et al., 2024](#)). If implemented optimally, web-based learning can increase students' interest in learning and provide opportunities for learning activities outside of school hours. ([Meduri et al., 2022](#)).

The potential of web-based learning media is promising in improving learning outcomes and student motivation, studies have shown the effectiveness of websites in improving various skills such as tactical skills, motivation and digital literacy. ([Hambali et al., 2022](#); [Setyasih et al., 2024](#); [Suripah & Susanti, 2022](#)). The development of web-based learning media, such as Wordwall for example, has been proven theoretically and empirically feasible to implement, with positive student responses and significant improvements in learning outcomes. ([Layyinnati, 2022](#)). The findings suggest that web-based learning media can serve as an effective alternative to enhance a range of student skills, offering an interactive and engaging experience that contributes to improved student performance and skills across a range of subjects.

Moreover, recent studies have explored differentiated learning as an effective teaching approach at various levels of education. Differentiated learning has been shown to improve student motivation, learning outcomes and teacher satisfaction. ([Faiz et al., 2022](#)). A meta-analysis of 10 national studies showed that differentiated learning significantly improved student performance at all levels, both elementary and secondary school ([Yunita et al., 2023](#)). At the university level, a study involving first semester PGSD students at Muhammadiyah Palangkaraya University found that differentiated learning significantly improved learning outcomes in

mathematics for elementary school. ([Ni'mah, 2024](#)). Although differentiated learning is a relatively new approach, it has primarily been applied as a strategy to improve classroom learning through action research. ([Yunita et al., 2023](#)). The findings suggest that differentiated learning is a promising pedagogical approach to fulfill a variety of student needs and improve student learning outcomes as well as a variety of student skills.

ESD is a multifaceted learning approach to solve global challenges through several main themes: environmental, social, and economic themes that are interrelated. ([Kioupi & Voulvoulis, 2019](#)). This approach emphasizes a systematic way of thinking to understand the complex correlations between the sustainability factors under study. ([Glavič, 2020](#)). ESD aims to develop several competencies such as critical thinking, collaboration, and future-oriented action ([Minott, 2023](#)). The research that has been conducted comes mainly from developed countries and focuses on areas of study such as environmental education, higher education, and sustainable development capacity. ([Yang & Xiu, 2023](#)).

The main issues in ESD include policy, cooperation, transformative learning, and capacity building. ([Glavič, 2020](#)). Effective implementation of ESD requires embedding the concept of sustainability into major disciplines and utilizing authentic assessment activities. ([Minott, 2023](#)). In general, ESD serves as a tool to transform society towards a sustainable society, in line with the UN Sustainable Development Goals (SDGs). ESD also emphasizes the important role of education in shaping a sustainable future. ([Kioupi & Voulvoulis, 2019](#)).

Research on ESD in biology education highlights several main areas. The integration of ESD into learning is crucial in improving students' understanding of environmental issues and fostering sustainable behavior. ([Cebrián et al., 2020](#)). Study highlights the importance of developing teachers' competencies in ESD to effectively integrate sustainability principles into learning practices ([Hallinger & Nguyen, 2020](#)). Research shows that the implementation of ESD in biology learning has a positive impact on students' action competencies for sustainability

and has potentially application in science learning (Olsson et al., 2022; S. Rahmawati et al., 2021).

2. RESEARCH METHOD

This research involved descriptive quantitative method. The subjects in this study were 10 high school biology teachers from several schools in Kebumen Regency and 95 tenth grade students of SMAN 1 Karanganyar, Kebumen Regency. The instruments used included teacher questionnaires, student questionnaires, and teaching module document analysis sheets. The teacher and student questionnaires used a Likert scale with four alternative answer choices, namely strongly agree, agree, disagree, and strongly disagree. The indicators for the teacher questionnaire are presented in Table 1.

Table 1. Teacher Questionnaire Indicator

No	Indicator
1	Teachers' understanding of differentiated learning
2	Teachers' understanding of ESD
3	Teachers' habits in teaching Biotechnology materials
4	Condition of supporting facilities and infrastructure
5	Potential website integration of differentiation and ESD

Table 2 explains the indicators used in the questionnaire for students.

Table 2. Student Questionnaire Indicator

No	Indicator
1	Student Learning Habits
2	Students' habits of using the website
3	Supporting Facilities and Infrastructure

Data collection techniques used in the study by distributing questionnaires to teachers and students with the help of google form, while for document analysis by asking for teaching modules used by teachers in teaching biotechnology. The questionnaire instrument because it uses a Linkert scale, the results of the questionnaire will be processed into a percentage, and the guidelines for categorizing the percentage results follow the following rules.

Table 3. Linkert Scale Categories

Percentage	Categories
81 – 100%	Very good
61 – 80%	Good
41 – 60%	Fair
21 – 40%	Deficient
0 – 20%	Very Poor

(Sugiyono, 2015)

3. RESULTS AND DISCUSSION

The first data to be discussed is the results of a questionnaire completed by teachers. The teacher questionnaire was designed with five indicators, namely teachers' understanding of differentiated learning, teachers' understanding of ESD, teachers' habits in teaching biotechnology material, support for facilities and infrastructure at school, and the potential of websites in learning. In general, the average results of the five indicators are presented as shown in Figure 1

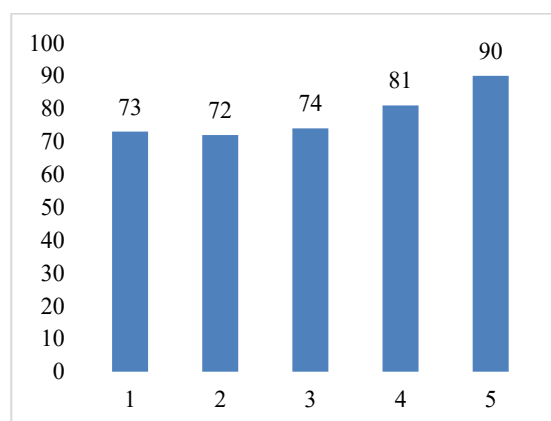


Figure 1. Percentage of Teacher Questionnaires for 5 Indicators

Description:

1. Teachers' understanding of differentiated learning
2. Teachers' understanding of the concept of ESD
3. Teachers' habit of teaching biotechnology
4. Supporting facilities and infrastructure
5. Potential for website implementation

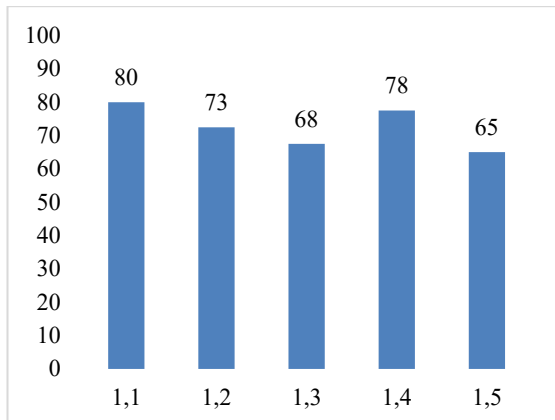


Figure 2. Percentage of Teacher Questionnaires for Indicators of Teachers' Understanding of Differentiated Learning

Description:

- 1.1. Understanding the concept of differentiated learning
- 1.2. Understanding of differentiation strategy
- 1.3. Understanding the differentiation approach
- 1.4. Understanding the relevance of differentiation in learning
- 1.5. Training on differentiated learning

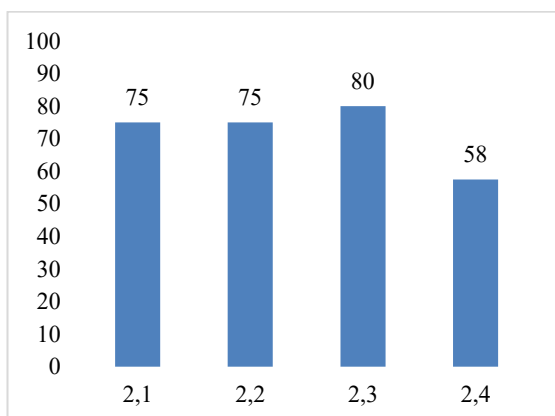


Figure 3. Percentage of Teacher Questionnaires for Indicators of Teachers' Understanding of ESD concepts

Description:

- 2.1. Understanding of ESD concept
- 2.2. Understanding of ESD topics
- 2.3. Approval of ESD Integration
- 2.4. Training on ESD

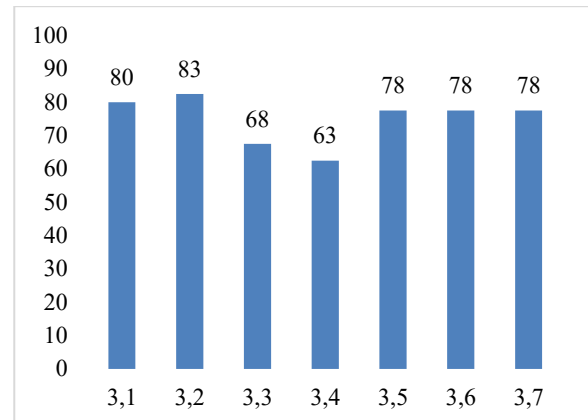


Figure 4. Percentage of Teacher Questionnaires for Indicators of Teachers' Habits of Teaching Biotechnology Materials

Description

- 3.1. Variety of methods
- 3.2. Use of printed media
- 3.3. Use of digital media
- 3.4. Implementation of Differentiation in learning
- 3.5. ESD integration in learning
- 3.6. Differentiation Implementation Challenges
- 3.7. ESD Implementation Challenges

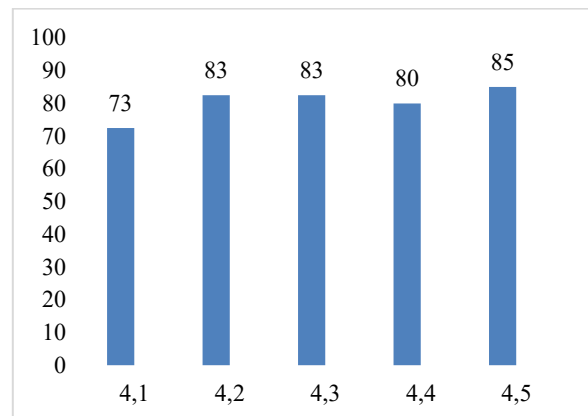


Figure 5. Percentage of Teacher Questionnaires for Indicators of Support for Facilities and Infrastructure at School

Description

- 4.1. Condition of teacher's cellphone/laptop
- 4.2. Internet Access at School
- 4.3. Availability of Presentation Media
- 4.4. Existence of Local Server
- 4.5. Presence of IT Expert in school

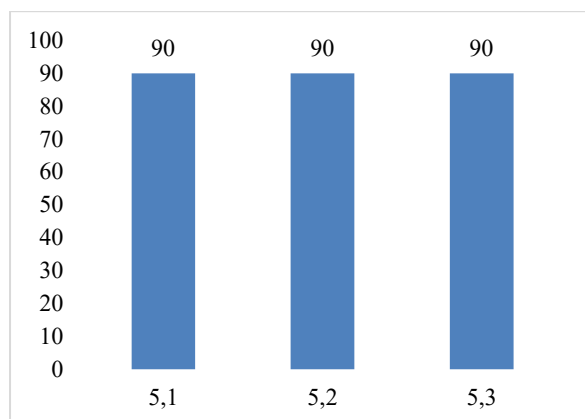


Figure 6. Percentage of Teacher Questionnaires for Potential Indicators of Implementation of ESD-oriented differentiation websites

Description

5.1. Differentiation and ESD Alternative Website

5.2. Ease of Website Access

5.3. Website Encourages Critical and Creative Thinking

In the first indicator related to teachers' understanding of differentiated learning, the average percentage is 73% (Figure 1) which belongs to the good category. The highest sub-indicator is teachers' understanding of the basic concepts of differentiation with an average of 80%, while the sub-indicator with the lowest average is training experience related to differentiated learning, which is 65% (Figure 2). From this data, it can be concluded that teachers have an understanding of differentiated learning not through training, but from other reference sources. Although teachers' understanding of the basic concepts of differentiated learning is good, training related to the implementation of differentiated learning is still lacking, so it becomes one of the challenges in classroom implementation. ([Hanafiah et al., 2024](#); [R. Rahmawati, 2023](#)).

The second indicator is to determine the extent of teachers' understanding of the concept of ESD. The results of the analysis show that in general, teachers' understanding of the concept of ESD is in the good category, namely 72% (Figure 1), slightly lower than the understanding related to differentiated learning, which shows that the term ESD is still less familiar to teachers. The sub-indicator with the highest percentage achievement is teachers' agreement to integrate ESD in biotechnology learning at 80%, while the sub-

indicator with the lowest percentage is the training that biology teachers have attended related to ESD with a percentage of only 58% (Figure 3), the sub-indicator with the lowest achievement. Several studies have shown that teachers in Indonesia still lack understanding of the concept of ESD, so teacher training to strengthen the basic concepts of ESD is needed. ([Amelia & Hamdu, 2021](#); [Saffanah & Hamdu, 2023](#)). Although ESD has been launched in 2015, massive socialization, especially for teachers, still needs to be improved to increase teachers' understanding of ESD.

The third indicator aims to capture teachers' habits in teaching biotechnology materials. The overall average for this indicator is 74% (Figure 1), falling into the good category. The implementation of a differentiated learning approach in the classroom is the sub indicator with the lowest percentage of 68%, in line with previous conditions, with a lack of understanding, which has implications for implementation that is not optimal in the classroom. Meanwhile, the use of digital media such as power point, websites, applications and YouTube obtained the highest average of 83 (Figure 4), in the very good category, meaning that teachers are accustomed to using digital learning media rather than print media such as books, printed teaching materials, and encyclopedias. The research shows that teachers' digital pedagogy competencies are essential for 21st century education. ([Rahayuningsih & Muhtar, 2020](#)). From these results, it can be concluded that biology teachers in Kebumen Regency have sufficient digital competence to implement digital learning.

The fourth indicator aims to capture the condition of infrastructure that supports the implementation of web-based learning or digital learning in general. Facilities and infrastructure play an important role in improving the quality of education and supporting effective learning processes in schools. ([Dwi Iwan et al., 2023](#); [Prihatini et al., 2022](#)). The results of the analysis obtained an average of 81% (Figure 1) which is in the very good category. The lowest sub-indicator is the availability of smartphones and laptops for both teachers and students which is considered inadequate, only at 73% (Figure 5), although the lowest but still in the good category. HP/laptop in web-based learning is indeed needed to access the website itself, but the lack of HP compatibility can

be given a solution with collaborative learning. The highest sub-indicator is the availability of IT experts in each school with 85% (Figure 5). The existence of IT experts is an important support for managing resources. Proper management of these resources is very important, including planning, procurement, use, inventory, maintenance and disposal ([Dwi Iwan et al., 2023](#)).

On the other hand, research shows that web-based learning media offers several advantages for education. It can integrate a variety of multimedia content, increasing student engagement and understanding. ([Idzi' Layyinnati, 2022](#); [Suripah & Susanti, 2022](#)). The fifth indicator explores the perceptions of biology teachers in seeing the potential use of ESD-oriented differentiated learning websites in learning biotechnology. This indicator obtained the highest percentage of the five indicators, namely 90% (Figure 1). This means that 9 out of 10 biology teachers who became respondents agreed that ESD-oriented differentiated learning websites have the potential to be applied in learning. Of the three sub-indicators, both statements about the website as an alternative integration of differentiated learning and ESD, ease of access, and the potential of the website to encourage students' critical and creative thinking skills, all obtained a percentage of 90% (Figure 6) which is included in the very good category. The potential of website-based learning media is very promising in improving learning outcomes and student motivation. Studies have shown the effectiveness of websites in improving various skills such as tactical skills, motivation and digital literacy ([Hambali et al., 2022](#); [Setyasih et al., 2024](#); [Suripah & Susanti, 2022](#)).

As a comparison to the teachers' answers, a questionnaire was also distributed to understand the students' perceptions. There are 3 indicators in the student questionnaire including student learning habits on biotechnology material, students' habit of using/accessing the website, and support for school facilities and infrastructure s shown in Figure 2. The results of the analysis for the student response questionnaire are presented in the following diagram;

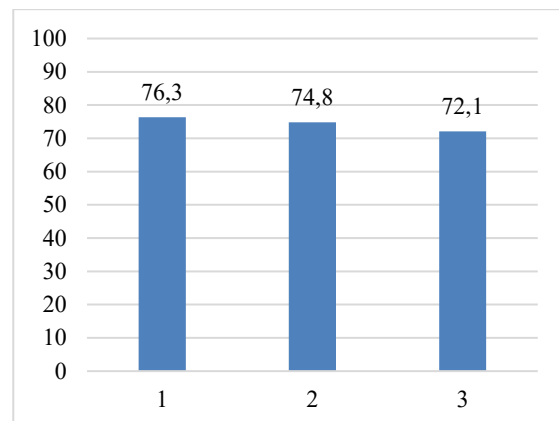


Figure 7. Percentage of Student Questionnaires for 3 Indicators

Description:

1. Student learning habits on biotechnology material
2. Students' habit of using/accessing the website
3. Support for school facilities and infrastructure

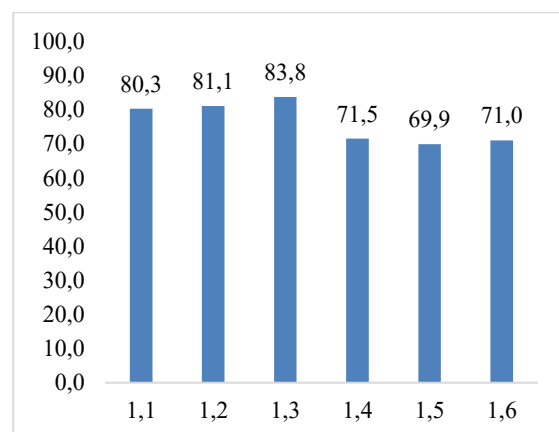


Figure 8. Percentage of Student Questionnaires for Indicators of Student Habits in learning biotechnology material

Description:

- 1.1. Learning experience with varied methods
- 1.2. Learning experience using printed media
- 1.3. Learning experience using digital media
- 1.4. Experience in implementing differentiated learning on biotechnology material
- 1.5. Experience of class grouping with variations
- 1.6. Experience integrating ESD in biotechnology learning

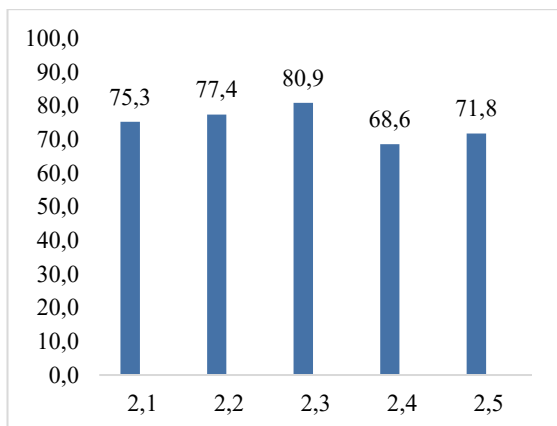


Figure 9. Percentage of Student Questionnaires for Indicators of Student Habits in using website media

Description:

- 2.1. Ability to access the website
- 2.2. Impression of the website
- 2.3. Interest in the website
- 2.4. Difficulty in accessing the website
- 2.5. Ability to understand features on the website

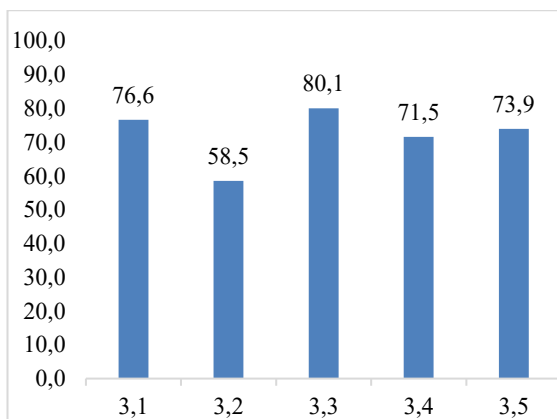


Figure 10. Percentage of Student Questionnaires for Indicators of Student Habits in using website media

Description:

- 3.1. Student HP / Laptop Condition
- 3.2. Internet Access at School
- 3.3. Availability of Presentation Media
- 3.4. Existence of Local Server
- 3.5. Existence of IT Experts at school

The first indicator describes students' learning habits, with an average percentage of 76.3% (Figure 7) which falls into the good category. The sub-indicator with the highest score is the experience of students learning with digital media, which is 83.8% (Figure 8), these results are in line with the teacher questionnaire which

proves that the use of digital learning media is already commonly used in biotechnology learning. Teachers are able to utilize digital learning media well. Meanwhile, the lowest sub-indicator is the experience of grouping students based on interests, learning styles, and learning readiness which only obtained an average score of 69.9% (Figure 8). These results can also confirm the results of filling out the teacher questionnaire which shows that the implementation of differentiated learning is still less than optimal, according to the results of the study that some teachers have successfully implemented differentiation in the aspects of products and learning environments, but for content and process differentiation is still a challenge due to lack of training, time constraints, and large class sizes. ([Sofiana et al., 2024](#)).

The second indicator explores students' habits in using website media, the average obtained is 74.8% (Figure 7). Figure 9 shows that the sub-indicator of student interest in websites is the indicator with the highest average achievement (80.9%), indicating that student interest in websites is relatively high. This result is in line with research showing that students generally show a positive attitude toward the use of digital media, with 77.08% expressing a positive view. ([Sahara & Thohir, 2022](#)). The next sub-indicators with the highest average are the impression of the website (77.4%) and the ability to access the website (75.3%), all of which are in the good category. This condition is in accordance with previous research that the website provides satisfaction and positive impressions and is able to improve understanding and learning outcomes at all levels. ([Mude et al., 2020](#); [Mulyahati & Zulfiani, 2023](#); [Samo et al., 2023](#); [Wulandari et al., 2023](#))

The last indicator explored was the condition of facilities and infrastructure from the students' perspective. The average result shows 72.1% (Figure 7), which is in the good category. The highest sub-indicator is the availability of presentation media at 80.1% (Figure 10), while the lowest sub-indicator is the availability of internet access at school which is only 58.5% (Figure 10). The results of interviews with the school facilities and infrastructure section conveyed that internet access for all students has a bandwidth of 100 MB which is distributed to all

classes, each class has its own router. The weak internet access felt by students is possible because the cable network to each class still uses old cables not yet using fiber optic cables, this year the arrangement of the cable network to be transferred to fiber optic cables will soon be realized. Effective management of educational facilities and infrastructure is very important to achieve educational goals and ensure the readiness of the learning process, because this has a positive impact on teaching and learning activities and ultimately improves the quality of education. (Dwiputri et al., 2022; Malau et al., 2022).

The results of the analysis of 3 writing module documents of biology teachers who teach at SMA Negeri 1 Karanganyar, Kebumen Regency show the following results:

Table 4. Teacher Teaching Module Document Analysis Results

No	Observation Aspect	Total	Percentage
1	Initial mapping activity	1	33%
2	Use of digital media	2	67%
3	Group differentiation	0	0%
4	Learning with a differentiated approach	2	67%
5	Differentiated assessment	2	67%
6	Integration of ESD issues	0	0%

Based on these results, it can be seen that the teacher's habit of using digital learning media is good (67%) reflected in the planned writing module, while for the implementation of differentiated learning in general is still not optimal, in the initial mapping activity only 33% of teachers appear in their planning, even for the formation of differentiated groups (interests, learning styles, learning readiness) no teacher plans in the teaching module. Yet studies show that integrated modules based on student learning styles can improve teaching quality and student achievement (Syadidah et al., 2024). For the implementation of differentiation approaches

such as content, process, and product as well as the accompanying assessment on student worksheets, it has shown 67%, which can be said to be good. As for the integration of ESD issues explicitly, it can be said that 0% of teachers plan, but if observed implicitly because biotechnology material must be closely related to environmental and social issues, it will appear even though it is not clearly written in the module. Studies have shown that differentiated learning modules can effectively support teachers in implementing in education (Basri et al., 2024). Therefore, it is important for teachers to develop teaching modules that facilitate students' learning needs. Likewise, the integration of ESD in the module is important because research shows that the implementation of ESD in biology learning has a positive impact on students' action competencies for sustainability, including sustainable knowledge and behavior. (Olsson et al., 2022). Good quality learning begins with good learning planning.

4. CONCLUSION

The conclusion of this study is that a good category was obtained for the five indicators measured in the teacher questionnaire. Similarly, from the student questionnaire, all three indicators showed favorable results. However, the document analysis revealed that while most teachers understood differentiation, they had not yet explicitly integrated ESD into their teaching. Based on these findings, it can be concluded that a differentiation-oriented ESD website can be applied in biotechnology education in the classroom.

5. ACKNOWLEDGEMENTS

Thank you to the Science Education study program at Postgraduate, PGRI University of Semarang and the State Senior Highschool 1 Karanganyar, Kebumen Regency, which is the research site that has facilitated the research conducted.

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