Quagga
Jurnal Pendidikan dan Biologi

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

Assessing Biodiversity E-Modules: PBL-Google Sites for Digital Literacy & Engagement

Lilia Krisna Sari[1,2*], Marlina Ummas Genisa[3], Meli Astiani[4]
[1,3,4]Master of Program Biology Education, Universitas Muhammadiyah Palembang, Indonesia
[2]SMAN 09 Ogan Komering Ulu, Baturaja, Palembang, Indonesia
*Corresponding author: liliasari14@guru.sma.belajar.id

APA Citation: Sari, L. K., Genisa, M. U., & Astiani, M. (2026). Assessing Biodiversity E-Modules: PBL-Google Sites for Digital Literacy & Engagement. *Quagga: Journal of Education and Biology*, 18(1), 61-71. DOI: 10.25134/quagga.v18i1.485.

Received: 27-07-2025 Accepted: 02-01-2025 Published: 07-01-2026

Abstract: *Digital revolution in education necessitates the utilisation of interactive and contextual learning media, particularly in the presentation of biological content, such as biodiversity. Nevertheless, traditional learning predominates, thereby diminishing student engagement in the educational process. This study seeks to evaluate the necessity for the creation of Problem-Based Learning (PBL) e-modules utilising the Google Sites platform to improve students' digital literacy and engagement in learning. The employed methodology is descriptive quantitative, involving the distribution of questionnaires to 80 students and 6 biology instructors at SMAN 1 and SMAN 9 OKU. The research findings indicate that most students exhibit a preference for digital learning resources and favour interactive learning approaches, including conversations and problem-solving activities. Furthermore, both students and educators concur on the necessity of creating digital learning resources that foster 21st-century competencies, including critical and collaborative thinking. The subject of biodiversity was recognised as particularly pertinent for development through the PBL methodology. This discovery underscores the necessity of incorporating digital technology in education to foster a more engaging, significant, and needs-based learning experience for pupils.*

Keywords: *Google Sites, Biodiversity, Educational Engagement*

1. INTRODUCTION

The rapid advancement of information technology has ushered in a digital revolution that permeates nearly every aspect of modern life, making its integration into education an undeniable necessity (Dr. Ranbir, 2024). In this evolving landscape, 21st-century education demands that digital technology transcends its traditional role as a mere supplementary tool, becoming instead a fundamental component of the teaching and learning process (Indarta et al., 2022; Keengwe, 2015). The core challenge facing contemporary education lies in fostering learning environments that cultivate essential 21st-century competencies, including critical thinking, creativity, communication, and collaboration, all through the adept application of technology (Peng et al., 2023; Straková & Cimermanová, 2018). As students navigate an increasingly technologically saturated world - engaging with social media, accessing information online, and utilizing various digital applications daily - a renewed optimism emerges within the educational sphere to adapt to the inherent learning characteristics of this digital age. Indeed, numerous studies affirm that the strategic use of technology in education can significantly enhance student motivation, engagement, and conceptual understanding s (Purwanti & Sholihah, 2021; Rohmatul Laila Negeri, 2022; Zhong et al., 2022). This technological integration empowers educators to craft flexible learning environments rich in visual and multimedia resources, while facilitating more personalized and contextualized learning (Meirbekov et al., 2022; Yaumi, 2018).

Quagga
Jurnal Pendidikan dan Biologi
p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

Despite the recognized benefits, the comprehensive incorporation of technology has not been uniformly achieved across all academic disciplines (Köse et al., 2018). This is particularly evident in subjects like biology, which inherently demand visual, interactive, and contextual media for effective instruction (Kono et al., 2016; Wong & Subramaniam, 2022). Biology encompasses complex content, such as biodiversity, that necessitates active and tangible student involvement. Biodiversity, a pivotal topic within the biology curriculum, presents unique instructional challenges due to its intricate connections with ecological principles, the taxonomy of living organisms, and abstract yet impactful environmental issues. While crucial for cultivating students' understanding of environmental conservation, traditional pedagogical methods, often relying on lectures and rote assignments, frequently fall short in effectively engaging students or deepening their interest and comprehension of this vital subject matter (Putra et al., 2018). This prevailing condition underscores a pressing need for the development of innovative educational media that align with the contemporary learning requirements and characteristics of today's students.

In response to this pedagogical gap, the utilization of e-modules as electronic instructional resources has demonstrated considerable potential to deliver content systematically, visually, and with pervasive accessibility, anytime and anywhere (Abyan Rofiyadi & Lestari Handayani, 2021; Hartati, 2022). Furthermore, the Problem-Based Learning (PBL) paradigm stands out as an educational strategy uniquely suited to foster the creation of interactive and contextual learning media (Uluçinar, 2023). PBL, as an educational methodology, fundamentally prioritizes the resolution of real-world, contextual problems as a foundational element in knowledge acquisition (Khasanah & Indah, 2024). Within this framework, students are actively encouraged to investigate, analyze, and resolve authentic situations, thereby significantly enhancing the relevance and depth of their learning experience (Savery, 2015; Wang, 2022).

The efficacy of PBL in biology instruction has been substantiated by its capacity to enhance students' critical, collaborative, and reflective thinking abilities. Research indicates that students engaging with the PBL approach exhibit improved conceptual comprehension and heightened engagement throughout the learning process (Uluçinar, 2023). This instructional technique actively promotes collaborative group work, facilitates dynamic discussions, and encourages constructive debate, ultimately generating a vibrant and participatory learning environment. The integration of such project-based learning with digital technology holds immense promise for enriching the overall learning experience, particularly when facilitated by intuitive and accessible digital platforms. Among these platforms, Google Sites presents a viable option for the creation of e-modules (Danev, 2024). Google Sites, an online platform, enables users to construct digital sites with remarkable simplicity and efficiency (Ghani et al., 2024). Its primary advantage lies in its ability to seamlessly integrate diverse media formats, including text, images, videos, and external links, into a unified page that is readily accessible to students across various digital devices (Kurniawati, 2020; Wahyuningsih & Harisanty, 2023; Harahap et al., 2024; Vikenso Ch. S. Taaraaungan et al., 2025). Moreover, Google Sites supports both autonomous and collaborative learning processes, as content can be accessed at any time and from any location, thereby augmenting flexibility in learning both within and beyond the traditional classroom setting.

However, despite the extensive exploration of digital learning media such as interactive e-books, ducational videos, and various educational applications (Abyan Rofiyadi & Lestari Handayani, 2021), a critical research gap remains. There is a distinct scarcity of literature conducting a comprehensive needs analysis for Problem-Based Learning (PBL) e-modules specifically utilizing the Google Sites platform, particularly for biodiversity content (Khairunnisa et al., 2024; Sari et al., 2023; Wardani et al., 2024). While previous studies have examined PBL or digital tools in isolation, few have investigated the specific integration of accessible web-based platforms like Google Sites to facilitate the contextual and inquiry-driven nature required for biodiversity education. Consequently, empirical evidence regarding the necessity of this specific

Quagga
Jurnal Pendidikan dan Biologi
p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

technological and pedagogical combination remains limited.

The imperative to integrate teaching methods that cultivate higher-order thinking skills with readily available digital platforms is a pressing necessity in contemporary education (Zainal Falah et al., 2025). Addressing this need is crucial, as the lack of such integrated resources hinders the potential for truly contextual biology instruction. Therefore, this study addresses this disparity by presenting a novel needs analysis for the development of Problem-Based Learning (PBL) e-modules using the Google Sites platform, with a specific focus on biodiversity. Unlike earlier studies that predominantly concentrated on application- or video-based media production, this research prioritizes the creation of problem-based digital teaching resources designed to promote contextual, interactive, and flexible learning. The anticipated outcomes of this needs analysis are expected to yield practical contributions to the development of highly pertinent learning media and to establish a robust foundation for the subsequent development of e-modules that effectively address the evolving requirements of students and educators in the digital age. By analyzing the specific needs of teachers and students, this research aims to inform a targeted initial design of the e-module, thereby emphasizing the critical role of technology as a transformative solution for future education. The existing digital literacy of students and their expressed keen interest in learning through interactive media establish a strong basis for the successful development of PBL-Google Sites e-modules, representing an innovative approach to tackling contemporary challenges in biology education.

2. RESEARCH METHOD

Research Design

This study used a descriptive quantitative methodology to understand the current learning environment in biology education before developing new instructional materials. This approach systematically investigates existing practices, views, and expectations of both educators and students regarding digital media utilization and biodiversity topics. The goal was to identify areas for innovation, particularly for an e-module centered on Problem-Based Learning (PBL) using Google Sites, designed to enhance visualization, contextualization, and interactivity. This method was chosen because it allows researchers to document real-world occurrences without manipulating variables, effectively discerning behavioral patterns and attitudes and providing numerical data that summarizes opinions to highlight differences between current and optimal learning designs.

Furthermore, this descriptive technique aligns perfectly with the Analysis phase of the ADDIE instructional design model, which heavily relies on a needs assessment. The study collected data on teachers' methods, the media they use, and the challenges they face, as well as students' engagement, preferred media, and impressions of digital learning. This detailed analysis of both teacher and student perspectives ensured that the proposed PBL-based e-module for biodiversity education would be targeted and problem-solving, guiding its structure and content to meet both pedagogical and technological standards. Ultimately, this comprehensive data collection provided a strong foundation for developing an e-module that supports student-centered learning and bridges the gap between current and optimal 21st-century learning practices.

Population and Samples

This study focused on improving digital education in a typical learning environment: high schools in Ogan Komering Ulu (OKU), South Sumatra, Indonesia. The research specifically targeted biology professors and students to understand the evolving needs of 21st-century education. The researchers employed a purposive sampling strategy, which is ideal for identifying participants with specific expertise. This allowed them to carefully select individuals whose knowledge and experience were directly relevant to the study's goals, ensuring the data collected would be rich and insightful.

The sample included six certified biology teachers with at least a decade of experience and advanced degrees in biology education. These educators were chosen for their deep understanding of teaching methodologies, student engagement, and the challenges of teaching biodiversity. Their insights were crucial for assessing the requirements of new digital learning tools. Additionally, 80 tenth-grade students from

Quagga
Jurnal Pendidikan dan Biologi
p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

SMAN 1 OKU and SMAN 9 OKU participated. These students were selected because biodiversity is formally introduced in the national curriculum at this grade level and because they had access to digital devices and internet connectivity, essential for evaluating the feasibility of digital learning interventions like e-modules using Google Sites.

The choice of these specific schools was also deliberate, as they offered reliable internet connectivity and a supportive environment for digital learning, evidenced by their participation in online learning during the COVID-19 pandemic. School administrators also expressed a strong interest in integrating more technology into their classrooms. By selecting both experienced educators and digitally-equipped students, the study aimed to create an e-module that was both relevant and applicable to real-world biology instruction and learning. This comprehensive approach, integrating teacher expertise and student experience, ensured the findings accurately reflected the target population and would effectively guide the development of the proposed PBL-based e-module.

Instruments

Researchers created distinct structured questionnaires specifically designed for teachers and students to collect data. The instruments comprised a combination of Likert-scale items, multiple-choice questions, and checklists. The items were crafted to investigate respondents' choices for learning media, their degrees of digital literacy, the instructional methodologies currently employed in biodiversity lessons, and their judgements regarding the efficacy of digital modules. The questionnaire's construction was informed by research instruments utilised in analogous studies of educational needs analysis and tailored to the setting of Indonesian high school biology teaching (Purwanti & Sholihah, 2021). The instruments were evaluated for content validity by experts in instructional design and subject matter specialists. Feedback was solicited to enhance the clarity, relevance, and alignment of the items with the research objectives. A pilot test was performed using a small sample group (excluded from the primary data collection) to assess the reliability and clarity of the questionnaires. The pilot findings were utilised to amend unclear questions and verify the internal consistency of each portion of the instrument.

The student questionnaire concentrated on metrics including the frequency of digital media utilisation, preferences for learning methodologies (e.g., video-based instruction, group discussions, problem-solving), experiences with project-based learning (PBL), and perspectives on the significance of digital education. The teacher questionnaire includes elements regarding teaching experience, utilisation of digital technologies in the classroom, issues associated with teaching biodiversity, and willingness to incorporate PBL approaches with online platforms like Google Sites.

The utilisation of organised and tested instruments enabled researchers to obtain an extensive array of quantitative data. The feedback from both educators and learners was crucial in determining the congruence (or incongruence) between current practices and required standards. This corresponds with Prastowo & Andriyani (2022), who emphasise the necessity of assessing both cognitive and behavioural variables in the creation of responsive educational interventions.

Procedures

The research was executed through multiple procedural phases to guarantee methodical and ethical data acquisition. An extensive literature study was performed to establish the theoretical framework and to pinpoint deficiencies in current research concerning e-module development, project-based learning, and digital education in biology. Subsequently, research instruments were developed and presented for validation by specialists in instructional design and biology teaching.

Upon validation, formal consent was secured from school principals and district education authorities in compliance with ethical research standards. A comprehensive briefing was conducted for participating instructors and students to elucidate the study's goal, secure informed consent, and safeguard the confidentiality and anonymity of participants' responses.

Data were gathered through the distribution of printed and online questionnaires, contingent upon participants' access to devices and internet

Quagga
Jurnal Pendidikan dan Biologi
p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

connectivity. This hybrid methodology facilitated inclusivity in data collecting, especially in schools with inconsistent digital infrastructure. Upon gathering the completed surveys, the responses were systematically organised, coded, and input into statistical software for analysis. A logbook was kept to monitor the progress of instrument distribution and response rates for transparency.

The techniques complied with ethical standards for educational research, as highlighted by Yaumi (2018), guaranteeing the respect of participants' rights throughout the process. The methodology corresponds with recent research on digital learning preparedness and instructional media production, emphasising the importance of mixed-format distribution and school-based consent for the execution of field-based research. The procedure is shown in the diagram in Figure 1.

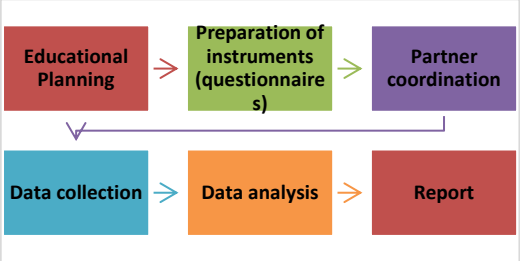

Figure 1. Data Collection Procedure

Data Analysis

The data obtained from the questionnaires were analysed with descriptive statistical methods. This entailed computing percentages and frequencies to discern trends and patterns in the responses. Key variables encompassed the ratio of students favouring digital learning compared to traditional formats, preferred instructional approaches (such as conversations or problem-solving), views of challenges in learning biodiversity, and general support for the creation of a PBL-based digital module. The data were analysed to determine specific needs and priorities that would inform the effective design of an e-module with Google Sites. This analytical methodology guarantees that instructional design is grounded in evidence and corresponds with real classroom conditions (Ardyagarani et al., 2024).

Descriptive statistics were selected as they offer a concise description of data features without seeking to infer causality. The analysis concentrated on converting raw data into comprehensible knowledge applicable to instructional design. This stage is essential for matching instructional media development with user expectations, as emphasised by Wahyuningsih & Harisanty (2023).

3. RESULTS AND DISCUSSION

The data collection approach produced quantitative information from 80 tenth-grade students and 6 biology teachers at SMAN 1 and SMAN 9 OKU. The data were examined by descriptive statistics and interpreted concerning the primary objectives of the research: determining the necessity for a PBL-based e-module on biodiversity and assessing the preferences, readiness, and views of students and teachers.

Responses from Students

All student participants (100%) indicated a preference for digital formats of learning media. In response to enquiries regarding the media that facilitated their learning, 85% of students expressed a pronounced preference for video-based explanations, interactive modules, and digital simulations. These results corroborate the findings of Wahyuningsih & Harisanty (2023), highlighting that multimedia-enhanced digital learning environments enhance engagement and conceptual comprehension. Students demonstrated considerable excitement for learning approaches that incorporate debate and problem-solving. Over 90% of students indicated that they acquired knowledge more successfully through collaborative efforts in addressing real-world biological issues. This validates the appropriateness of the Problem-Based Learning (PBL) methodology, which fosters critical thinking, cooperation, and contextual learning.

Remarkably, 85% of students believed that their present classroom instruction inadequately addressed their digital learning requirements or preferences. Numerous individuals indicated that traditional resources, such as printed worksheets and textbook readings, were less stimulating. These insights affirm the transformation in learner expectations in the digital age and suggest a necessity for instructional redesign employing technology-enhanced, student-centered pedagogies (Indarta et al., 2022). The results are shown in Figure 2 and Figure 3.

Quagga
Jurnal Pendidikan dan Biologi

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

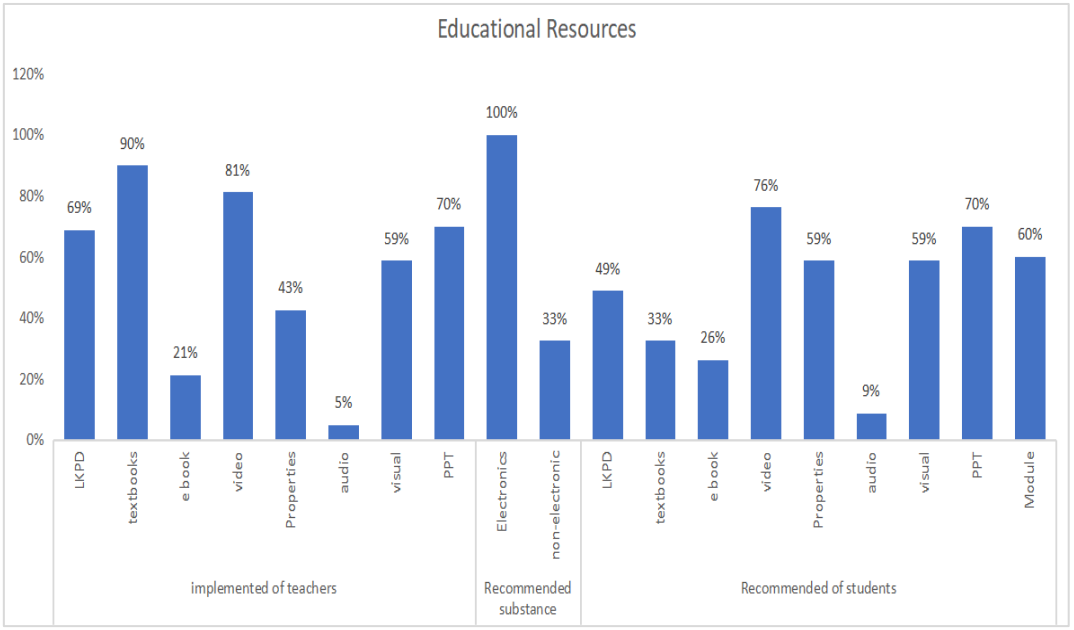

Figure 2. Results of the Student Needs Analysis Questionnaire Regarding Teaching Materials

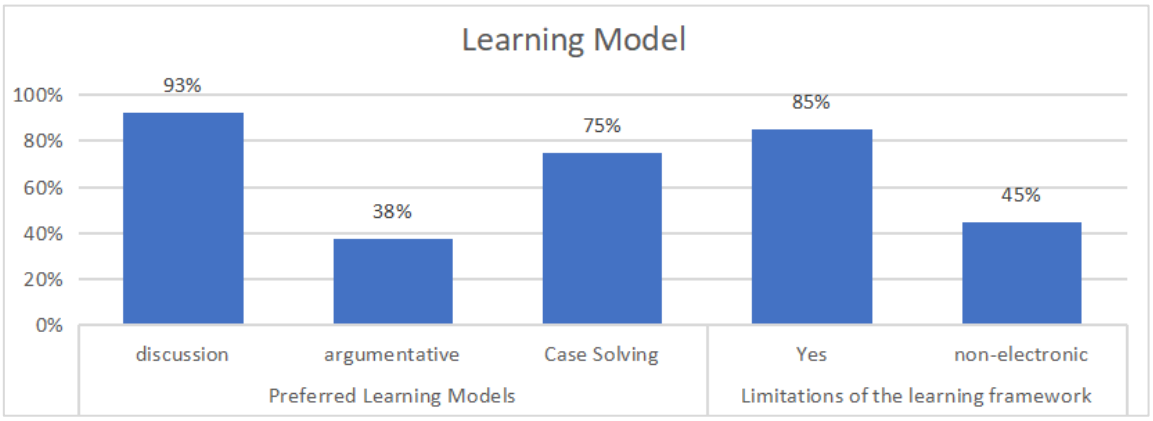

Figure 3. Results of the Student Needs Analysis Questionnaire Regarding Learning Models

Educator's Feedback

From the educators' perspective, the results indicated that 100% of respondents utilised printed textbooks and LKPD (student worksheets) as their principal teaching resources. Although several indicated the incorporation of films and presentations into their instruction, merely 33% had endeavoured to produce their own digital content. The restricted utilisation of digital technologies is frequently ascribed to time limitations, insufficient technical assistance, and an absence of professional development in educational technology (Prastowo & Andriyani, 2022).

All educators conveyed robust endorsement for the implementation of digital learning advances. They recognised that students exhibited greater enthusiasm in interactive learning environments and concurred that biodiversity elements may be more effectively taught through problem-based and digital forms. Furthermore, all teachers concurred that employing an e-module with integrated Project-Based Learning on a user-friendly platform such as Google Sites would be advantageous, particularly for accessibility, flexibility, and interaction. Figure 4 shows the results of the teacher's questionnaire.

Quagga
Jurnal Pendidikan dan Biologi

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

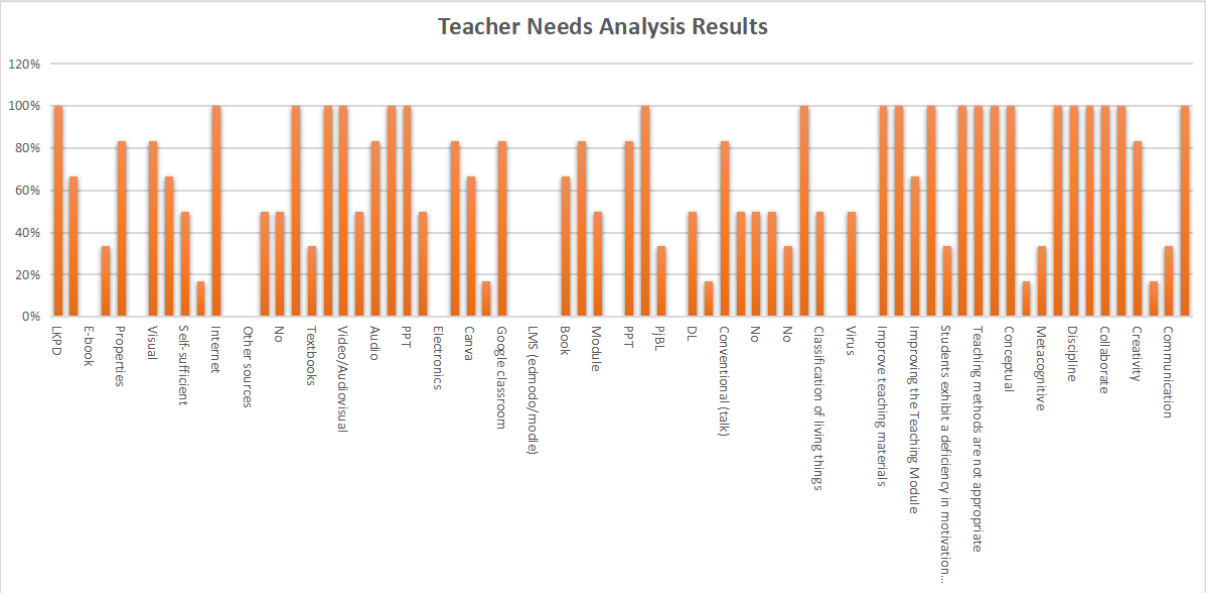

Figure 4. Results of the Teacher Needs Analysis Questionnaire Models

Summary of Needs Analysis

Triangulation of student and instructor replies indicates a significant necessity for the creation of an e-module on biodiversity based on the PBL model. The alignment of instructor recognition and student necessity enhances the capability of this module to address current educational deficiencies. The results emphasise the necessity of employing technology not merely to digitise current processes but to innovate them in ways that enhance learning outcomes (Ardyagarani et al., 2024). This aligns with Sari et al. (2023), who discovered that the integration of PBL with digital modules improves students' motivation, retention, and problem-solving abilities, particularly in relation to abstract biological subjects such as biodiversity. The findings of this study substantiate the premise that successful digital learning design must correspond with the cognitive and emotional requirements of learners.

In conclusion, the findings validate the imperative and immediacy of creating an innovative, student-centered e-module that employs the Problem-Based Learning approach and is hosted on an accessible, interactive platform such as Google Sites. This corresponds with 21st-century educational objectives and immediately addresses the contextual requirements identified in the biology classrooms of SMAN 1 and SMAN 9 OKU. Based on student needs for the module shown in Figure 5.

Quagga
Jurnal Pendidikan dan Biologi

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

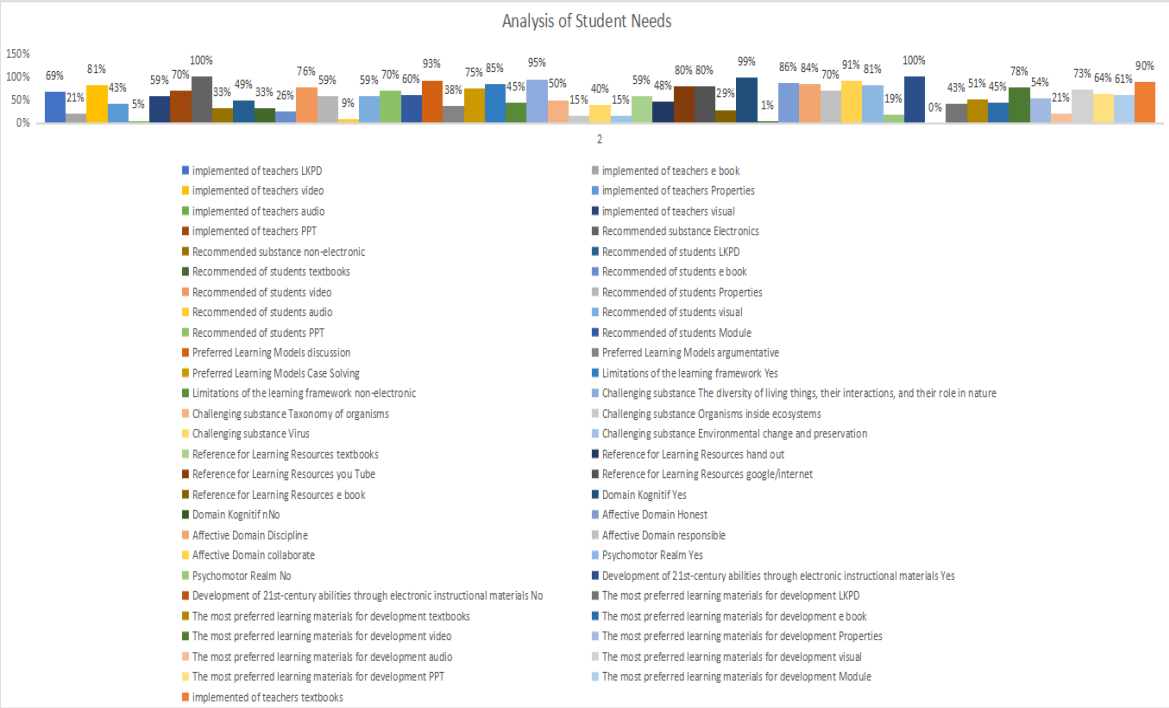

Figure 5. Results of the Student Needs Analysis Questionnaire Regarding the Development of e-modules to Improve Digital Literacy and Learning Interest

Research Novelty

This study is different from others because it doesn't just digitize textbooks into static electronic formats (PDFs). Instead, it carefully matches the media format to specific cognitive and emotional bottlenecks found in the needs analysis. First, the study looks at the exact "challenging substances" that students named, which are the Taxonomy of Organisms and Diversity of Living Things. This study goes beyond generic e-learning by using the students' favorite formats—Modules (90%) and Video (78%)—to focus on these hard topics. Second, even though many e-modules only focus on cognitive gains, this one stands out because it directly connects the Affective Domain to the learning loop. The data substantiates a mutual agreement among educators and learners regarding the imperative of cultivating Discipline and Collaboration. The e-module is new because it has two functions: it helps students learn about complex biological classification by letting them interact with it, and it also helps students build their character and independence, which is something that is often missed in standard digital media development.

What this means for biology teachers in real life The results of this study have important practical implications for Biology teachers, especially when it comes to overcoming the teaching problems shown in Figure 4. Teachers clearly stated that "Students exhibit a deficiency in motivation" (100%) and recognized that current "Teaching methods are not appropriate" (100%). The practical implication of this PBL-based e-module is that it functions as a direct intervention tool to rectify this motivational deficiency. Teachers can get students more involved in class without having to learn how to make complicated content from scratch by switching from text-heavy resources to the interactive, video-assisted formats that students like. Also, the fact that 93% of students prefer Discussion and 75% prefer Case Solving means that the teacher's role needs to change from being the main source of information to being a guide for inquiry. This e-module makes this change possible by moving the teaching of basic content (like Classification of Living Things) to the digital platform. This frees up valuable class time for teachers to lead the collaborative and problem-solving activities that students really want.

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

4. CONCLUSION

This study indicates an immediate necessity for the creation of novel digital learning resources, namely a biodiversity e-module utilising the Problem-Based Learning (PBL) framework. Students demonstrated a distinct preference for interactive and multimedia learning aids that augment their engagement in conversations, inquiry, and problem-solving activities. In contrast, teachers exhibited little proficiency in utilising digital tools; yet, they demonstrated a favourable disposition and willingness to embrace contemporary methodologies consistent with 21st-century education.

The congruence between student requirements and instructor preparedness underscores the necessity of creating a PBL-oriented e-module using the Google Sites platform. This program aims to deliver a flexible, engaging, and student-centered educational experience. Furthermore, it possesses the capacity to enhance pupils' digital literacy alongside their critical thinking and collaboration abilities—essential talents in the contemporary digital environment. These recommendations seek to render biology education more contextual, adaptive, and pertinent to the requirements of contemporary learners.

5. ACKNOWLEDGEMENTS

Our sincere gratitude is extended to State Senior High School 9 Ogan Komering Ulu, Baturaja, South Sumatra, Indonesia, and the Master's Program in Biology Education, Universitas Muhammadiyah Palembang, Palembang, Indonesia.

6. REFERENCES

Abyan Rofiyadi, Y., & Lestari Handayani, S. (2021). *Pengembangan Aplikasi E-Modul Interaktif Berbasis Android Materi Sistem Peredaran Darah Manusia Kelas V Sekolah Dasar*.

Danev, N. (2024). Google Sites as an Educational Tool in the Context of Traditional and Project-based Education. *Pedagogika-Pedagogy*, *96*(7), 1005–1018. https://doi.org/10.53656/ped2024-7.09

Dr. Ranbir. (2024). Educational Technology Integration: Challenges and Opportunities. *Innovative Research Thoughts*, *10*(2), 75–79. https://doi.org/10.36676/irt.v10.i2.1406

Ghani, M., Fakhruzzaman, M. N., Maryamah, Susanto, P. D., & Basuki, L. S. K. (2024). THE USE OF GOOGLE SITES FOR TEACHERS AND ADMINISTRATIVE PERSONNEL AS AN EFFORT FOR STUDENT DATA MANAGEMENT EFFICIENCY AT SMPN 19 SURABAYA & SMPN 52 SURABAYA. *Jurnal Layanan Masyarakat (Journal of Public Services)*, *8*(4), 486–500. https://doi.org/10.20473/jlm.v8i4.2024.486-500

Harahap, A. N., Nurdalilah, N., & Lubis, S. S. (2024). Development of Web-Based Learning Media Using Google Sites for Lines and Angles. *JDIME: Journal of Development and Innovation in Mathematics Education*, *2*(1), 26–36. https://doi.org/10.32939/jdime.v2i1.4116

Hartati, N. (2022). Implementasi E-Modul Interaktif dalam Meningkatkan Motivasi dan Hasil Belajar Siswa pada Pembelajaran Biologi di SMA Negeri 1 Gondang. *Jurnal Pendidikan Madrasah*, *7*(2).

Indarta, Y., Jalinus, N., Waskito, W., Samala, A. D., Riyanda, A. R., & Adi, N. H. (2022). Relevansi Kurikulum Merdeka Belajar dengan Model Pembelajaran Abad 21 dalam Perkembangan Era Society 5.0. *EDUKATIF : JURNAL ILMU PENDIDIKAN*, *4*(2), 3011–3024. https://doi.org/10.31004/edukatif.v4i2.2589

Keengwe, J. (Ed.). (2015). *Handbook of Research on Educational Technology Integration and Active Learning*. IGI Global. https://doi.org/10.4018/978-1-4666-8363-1

Khairunnisa, K., Winarni, W., & Murniati, N. (2024). *Pengembangan Lembar Kerja Peserta Didik Berbasis STEM Pada Materi Inovasi Teknologi Biologi Untuk Siswa SMA*.

Khasanah, U., & Indah, N. K. (2024). *PENGEMBANGAN E-MODUL BERBASIS PROBLEM BASED LEARNING PADA MATERI KEANEKARAGAMAN HAYATI UNTUK MELATIH BERPIKIR KRITIS PESERTA DIDIK*. https://ejournal.unesa.ac.id/index.php/bioedu

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

Kono, R., Mamu Dan Lilies, H. D., & Tangge, N. (2016). *PENGARUH MODEL PROBLEM BASED LEARNING (PBL) TERHADAP PEMAHAMAN KONSEP BIOLOGI DAN KETERAMPILAN BERPIKIR KRITIS SISWA TENTANG EKOSISTEM DAN LINGKUNGAN DI KELAS X SMA NEGERI 1 SIGI*.

Köse, E. B., Çetin, G., & Yünkül, E. (2018). A Content Analysis of Studies Related to Educational Technologies in Biology Education. In *Technologies in Biology Education. Journal of Educational Technology & Online Learning* (Vol. 1, Issue 2). http://dergipark.gov.tr/jetol

Meirbekov, A., Maslova, I., & Gallyamova, Z. (2022). Digital education tools for critical thinking development. *Thinking Skills and Creativity*, *44*, 101023. https://doi.org/10.1016/j.tsc.2022.101023

Peng, R., Abdul Razak, R., & Hajar Halili, S. (2023). Factors influencing in-service teachers' technology integration model: Innovative strategies for educational technology. *PLOS ONE*, *18*(8), e0286112. https://doi.org/10.1371/journal.pone.0286112

Purwanti, S., & Sholihah, M. (2021). PENGEMBANGAN LKPD ELEKTRONIK DENGAN PENDEKATAN STEM BERBASIS PROJECT-BASED LEARNING MATERI ENERGI DAN PEMANFAATANNYA. *Taman Cendekia: Jurnal Pendidikan Ke-SD-An*, *5*(2), 670–685. https://doi.org/10.30738/tc.v5i2.8826

Rohmatul Laila Negeri, A. S. (2022). Implementation of Problem Based Learning to Improve Studens' motivation in Learning Science. In *SHEs: Conference Series* (Vol. 5, Issue 5). https://jurnal.uns.ac.id/shes

Sari, J., Mildawati, T., Widyawati, D., Suwitho, Laily, N., & Triyonowati. (2023). Community Empowerment Through Digital Marketing Optimization-Based Socio-preneurship Training. *South Asian Journal of Social Studies and Economics*, *20*(4), 90–102. https://doi.org/10.9734/sajsse/2023/v20i4745

Straková, Z., & Cimermanová, I. (2018). Critical thinking development-a necessary step in higher education transformation towards sustainability. *Sustainability (Switzerland)*, *10*(10). https://doi.org/10.3390/su10103366

Uluçinar, U. (2023). The Effect of Problem-Based Learning in Science Education on Academic Achievement: A Meta-Analytical Study. *Science Education International*, *34*(2), 72–85. https://doi.org/10.33828/sei.v34.i2.1

Vikenso Ch. S. Taaraaungan, Olfiana Bastian, Tesalonika Maengkom, & Grace Christien Sumakul. (2025). Penerapan Google Sites sebagai Solusi Teknologi Pembelajaran Berbasis Web. *Jurnal Manuhara : Pusat Penelitian Ilmu Manajemen Dan Bisnis*, *3*(3), 88–97. https://doi.org/10.61132/manuhara.v3i3.1876

Wang, S. (2022). Critical Thinking Development Through Project-Based Learning. *Journal of Language Teaching and Research*, *13*(5), 1007–1013. https://doi.org/10.17507/jltr.1305.13

Wardani, R. K., Purwanto, Soelistijo, D., Tang, A., & Mu'tashimbillah, M. (2024). Digital Innovation in Education: The Impact of Problem-Based Learning Enhanced by Google Sites on Students' Critical Thinking in Seismic Studies. *Future Space: Studies in Geo-Education*, *1*(4), 454–467. https://doi.org/10.69877/fssge.v1i4.41

Wong, C. P., & Subramaniam, R. (2022). Use of technology in biology education–case of infrared thermal imaging. *Journal of Biological Education*, *56*(3), 340–352. https://doi.org/10.1080/00219266.2020.1808510

Yaumi, M. (2018). *Media dan Teknologi Pembelajaran* (S. F. S. Sirate, Ed.; 1st ed.). Prenadamedia Group.

Zainal Falah, Syahlarriyadi, & Anna Ropitasari. (2025). STRATEGI PEMBELAJARAN INOVATIF BERBASIS TEKNOLOGI DIGITAL. *SYAIKHONA: Jurnal Magister Pendidikan Agama Islam*, *3*(1), 16–31. https://doi.org/10.59166/syaikhona.v3i1.284

Zhong, T. C., Mat Saad, M. I., & Che Ahmad, C. N. (2022). Integrating technology-mediated learning in biology education (histology): A systematic literature review. *EDUCATUM Journal of Science, Mathematics and*

p-ISSN 1907-3089, e-ISSN 2615-5869
Vol 18, No. 1, 2026, pp 61 - 71
Available online https://journal.fkip.uniku.ac.id/quagga
DOI: 10.25134/quagga.v18i1.485

Technology, *9*(1), 48–57. https://doi.org/10.37134/ejsmt.vol9.1.5.2022