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Needs Analysis for the Development of a Project-Based Learning–Based E-Module on Virus Topics as Teaching Material for Grade X (Phase E) Senior High School Students

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ABSTRACT

Virus materials are inherently abstract and present considerable challenges for Grade X (Phase E) senior high school students when taught using conventional instructional methods. Therefore, effective instruction on virus concepts requires innovative teaching materials that facilitate conceptual understanding and promote active learning. One promising medium is an electronic module (e-module). Accordingly, this study aimed to conduct a needs analysis for developing a Project-Based Learning (PjBL)-based e-module on virus topics as instructional material. The study used a descriptive, quantitative design to examine the need to develop the proposed e-module. The analysis investigated current learning practices, students' learning experiences, perceptions of e-modules, and the need for a virus e-module integrated with the PjBL model. Participants included 33 students and 15 biology teachers. Data were collected through questionnaires distributed via Google Forms and analyzed using descriptive quantitative techniques. Results showed that 97% of students experienced difficulties understanding virus material. Furthermore, all students (100%) reported the need for additional learning resources and preferred e-modules containing visual representations, instructional videos, and interactive exercises. Most students also favored resources that were accessible anytime, anywhere via digital devices. Teachers likewise emphasized the need for e-modules that provide clearly structured project stages, contextual case studies, and standardized project report formats to support PjBL implementation. These findings indicate that developing a PjBL-based e-module is essential to enhance biology learning effectiveness, support independent learning, and help students develop competencies aligned with modern educational demands in secondary education contexts, and strengthen engagement with complex biological concepts through project activities and reflection.

Keywords: E-module, Project-Based Learning, Viruses, Needs Analysis, Biology Learning

Introduction

Biology instruction in senior schools should collaborate innovative pedagogical models and digital learning resources to support students' understanding of abstract concepts, including virus materials, by promoting active Engagement through Project-Based Learning (PjBL). In response to 21st-century educational demands, learning should also develop critical thinking, creativity, collaboration, and communication skills through the integration of information and communication technology (ICT), particularly interactive e-modules featuring visualizations, simulations, and project-based activities (Thornhill-Miller et al., 2023). Supported by teachers' pedagogical and technological competencies, this integration can enhance students' conceptual understanding of virus structure, replication, and their impact on living organisms (Ramaila & Molwele, 2022).

The availability of interactive e-modules, especially on virus-related topics, remains scarce in many schools, with the consequence that such students continue to rely on traditional lecture-based teaching styles which hinder hands-on visualization and manipulation of theoretical biology concepts (Akhmadkulovna, 2024). Despite the innovation in teaching methods promoted by Merdeka Belajar, the use of PjBL is still quite low, as teachers tend to transmit more content than a student-centered approach, resulting in less student engagement and less training in higher-order thinking (Trisnayanti, N., P. et al., 2025). Additionally, a lack of access to technological infrastructure and limited teacher competencies in the preparation and application of e-modules are barriers to the successful integration of ICT use.

In the context of biology education, learning is more effective when students have access to interactive e-modules that facilitate understanding of abstract concepts, such as those related to viruses (Pratamadita & Dwiningsih, 2022; Sholikhah et al., 2024). Project-Based Learning (PjBL) is an instructional model that can be effectively employed to support students' comprehension of abstract biological content, including virus materials. This approach enhances student engagement by actively involving learners in authentic, project-oriented activities closely connected to real-world issues related to viruses (Almulla, 2020; Handayani et al., 2025). Accelerating the implementation of PjBL is essential to ensure students maintain the momentum required to master 21st-century competencies, specifically critical thinking, creativity, and collaborative (Almulla, 2020; Fatonatullaillah et al., 2025; Helmira & Haviz, 2025; Thornhill-Miller et al., 2023).

Ideal learning environments effectively integrate technological advancements into the delivery of instructional content. In this regard, information and communication technology (ICT) plays a crucial role in supporting and enhancing the learning process. (Al-Rahmi et al., 2020; Rana & Rana, 2020). The rapid growth of information and communication technology (ICT) in the 21st century has driven the emergence of innovative instructional materials, such as electronic modules (e-modules) (Osmizein & Iskarni, 2022). E-modules are digital learning resources in the form of electronic books that students can access and read at any time and in various learning contexts (Trilestari & Fitriyah Almunawaroh, 2020). E-modules enriched with visual elements such as images, videos, tables, diagrams, and interactive exercises contribute to more engaging and enjoyable learning experiences. One of the main advantages of e-modules is their high accessibility and portability, which allows students to revisit and study learning materials according to their individual learning needs (Nugroho et al., 2023). Additionally, e-modules offer environmental and economic benefits, as they reduce the need for paper and printing, making them more cost-effective and user-friendly (Adeningsih et al., 2024).

The use of interactive learning media, such as e-modules, plays a crucial role in facilitating students' understanding of abstract concepts, including virus materials (Suwandi et al., 2024). Interactive e-modules are designed to present learning content in a more engaging and comprehensible manner, thereby enhancing students' motivation and learning outcomes (Delita & Berutu, 2022; Mahendri et al., 2022). In the context of biology education, interactive e-modules—particularly those focused on virus material—support students in understanding

complex, abstract biological concepts (Irmasari et al., 2023). Moreover, interactive e-modules enable students to connect theoretical knowledge with practical applications through appealing visualizations, interactive exercises, and relevant case studies (Aulia & Linda, 2023; Herlina & Abidin, 2024). Consequently, integrating interactive e-modules into biology instruction improves learning quality and deepens students' understanding of the subject matter (Irdawati et al., 2023; Rawat et al., 2023).

The integration of Project-Based Learning (PjBL) within e-modules is paramount for studying viruses, serving as the bridge between abstract microscopic theory and real-world biological phenomena. While e-modules excel at visualizing the elusive morphology of viruses, embedding the PjBL framework provides contextualization (Suwandi et al., 2024). This synergy encourages engagement, as students are guided toward the synthesis of creative artifacts supported by interactive, intuitive content (Delita & Berutu, 2022; Mahendri et al., 2022). Beyond facilitating mastery of complex abstractions, this approach empowers students to explore the topic via dynamic simulations and relevant case studies (Irmasari et al., 2023). Ultimately, it hopes that the e-module can facilitate the translation of theoretical constructs into tangible field solutions, significantly elevating instructional efficacy and student outcomes (Aulia & Linda, 2023; Herlina & Abidin, 2024; Rawat et al., 2023).

Based on previous studies and field observations, several practical challenges have been identified in the current instructional context. First, the limited availability of instructional media has led many schools to lack interactive e-modules on virus materials, resulting in continued reliance on conventional teaching approaches (Pratama et al., 2024; Saputra & Octavia, 2024). Second, traditional instructional models often encourage teachers to employ lecture-based methods more frequently than active learning approaches such as Project-Based Learning (PjBL), which may reduce student engagement and participation (Arief et al., 2024; Ferreira & Canedo, 2020). Third, many teachers face challenges due to insufficient competencies in developing and utilizing e-modules, as well as in effectively implementing PjBL in classroom instruction (Muzijah et al., 2020; Selano et al., 2024).

The lack of interactive e-modules aligned with students' needs and curriculum demands, together with the gap between the expected implementation of Project-Based Learning (PjBL) and the prevailing use of limited instructional methods, represents a major challenge in current biology instruction. These issues are further compounded by unequal access to technology, disparities in technological competence between teachers and students, and limited access to systematic training. To address these challenges, this study develops a PjBL-based e-module designed to improve instructional quality, foster active learning, and support the effective integration of technology in biology education.

Within this context, the study aims to identify students' and teachers' needs related to a Project-Based Learning (PjBL)–based e-module on virus topics. Furthermore, it aims to develop a curriculum-aligned PjBL-based e-module tailored to the characteristics of Grade X (Phase E) senior high school students, examine its effectiveness in improving students' conceptual understanding of viruses, and offer practical guidance for teachers on implementing the e-module and addressing potential challenges.

Methods

This research is a type of quantitative descriptive research. The research focused on collecting information for a needs analysis related to the development of an e-module, including the identification of general learning activities for viruses, students' experiences and perceptions of e-modules, expectations and needs regarding e-modules, and specific requirements for e-modules based on Project-Based Learning (PjBL).

The student sample consisted of 33 students from Grade X (Phase E), Class X E1, at SMA Negeri 1 Polokarto during the 2024/2025 academic year. The teacher sample included 15 biology teachers from public and private senior high schools across Sukoharjo Regency.

Data were collected through structured questionnaires administered to explore teachers' and students' perceptions of learning challenges and the instructional materials currently in use. The needs analysis questionnaires were distributed online via Google Forms to 33 Grade X (Phase E) students from Class X E1 and 15 teacher participants in February 2025.

Data from the student needs questionnaire, comprising closed-ended multiple-choice items, were analyzed by calculating response percentages. Meanwhile, to analyze open-ended questions, a word cloud generator application was used to identify the most frequently used answers by respondents. Data were analyzed using percentage analysis with the following formula:

$P = \frac{n}{N} X\ 100\ \%$

P = Percentage

n = Total score obtained

N = Maximum possible score (Arikunto, 2010)

Results and Discussion

This study employed an online needs analysis survey administered via Google Forms and disseminated through WhatsApp to 33 Grade X (Phase E) students from Class X E1 at SMA Negeri 1 Polokarto and 15 senior high school biology teachers in Sukoharjo Regency. The study aimed to examine students' and teachers' needs as a basis for developing a Project-Based Learning (PjBL)–based e-module for virus instruction at the senior high school level. The research was limited to the initial stage of e-module development, focusing on data collection to identify the characteristics of an interactive e-module that users require. The results of the student needs analysis are presented in Table 1.

Table 1. Results of the student needs on e-module requirements

No.	Question	Answer
1.	Do you find it difficult to learn biology, particularly virus-related topics?	97 % of students responded "Yes."
2.	What learning approaches are used by your biology teacher during classroom instruction?	87,9 % lecture-based instruction, 78,8 % discussion-based learning, and 45,5 % presentation
3.	Do you need instructional materials that help you learn biology content?	100 % of students responded "Yes."
4.	What types of instructional materials are provided by the school?	97% of students reported using printed textbooks, while smaller proportions indicated the use of student worksheets (LKPD) (9.1%), PowerPoint presentations (12.1%), PDF materials (18.2%), and e-modules (21.2%)
5.	Do you think smartphones are necessary in the current era and can facilitate access to biology learning materials anytime, anywhere?	100 % of students responded "Yes."
6.	Do you believe that e-modules can help you learn more independently?	100 % of students responded "Yes."
7.	In your opinion, is it important to use e-modules as instructional materials that include simulations, images, and engaging videos for learning activities?	97 % of students responded "Yes."
8.	Can the e-modules you use be easily accessed through the internet available at school?	69,7 % of students responded "Yes."
9.	Do you consider it important for e-modules to include a variety of content formats (text, images, tables, graphs, videos, and audio)?	100 % of students responded "Yes."

No.	Question	Answer
10.	What type of e-module format do you prefer?	78.8% of students favored e-modules featuring attractive images and illustrations, while 21.2% preferred interactive e-modules that incorporate videos and quizzes.
11.	What kind of e-module design or appearance do you find attractive and motivating for learning?	Students indicated that the e-module should include images, text, videos, and tables, presented in an engaging design that is easy to use and understand, and accompanied by clear, comprehensive explanations to support their understanding of the learning material.
12.	Do you need concept maps or diagrams to help you understand the structure of the learning material?	All students indicated that this feature is highly necessary
13.	How important do you consider the inclusion of varied content formats (text, images, videos, and audio) in an e-module?	It is considered important because it facilitates ease of learning
14.	Do you need to practice questions with increasing levels of difficulty, including higher-order thinking skills (HOTS) items?	Most students reported that this feature is necessary to support the development of their thinking abilities
15.	Do you understand the material better when quizzes or interactive exercises are included in the e-module?	Most students reported the need for interactive e-modules to enhance their comprehension of the subject matter

The interview results indicate that 97% of students experience difficulties understanding the virus. This finding suggests that virus material is abstract and conceptually complex, thereby requiring more innovative instructional approaches to address student's limited conceptual understanding. Students reported that the abstract nature of virus concepts contributed to their learning difficulties, reflected in low mastery levels, as most students achieved below-average scores on virus assessments. This condition underscores the urgent need for interactive, technology-integrated instructional media that support visualization and contextual learning to improve students' conceptual understanding (Pratiwi, et al., 2024). The results of the assessment of students' understanding of viruses are presented in Table 2.

Table 2. Results of students' assessment on virus materials

No.	Answer key	Number of Children Who Answered the Questions	Number of Children Who Answered the Questions Correctly	Percentage of Correct Answers	Mean Percentage Score	Preliminary Conclusions
Materials: Characteristics and Structure of Virus						
1.	C	33	6	18,18		The material needs to be further explored
2.	A	33	17	51,52		
3.	C	33	11	33,33	41,82%	
4.	D	33	12	36,36		
5.	A	33	23	69,70		
Materials: Virus Replication						
6.	C	33	6	18,18		The material needs to be further explored
7.	A	33	25	75,76		
8.	A	33	25	75,76	50,30%	
9.	C	33	5	15,15		
10.	A	33	22	66,67		
Materials: Roles of Viruses						
11.	B	33	15	45,45	52,73%	

12.	B	33	17	51,52		The material
13.	A	33	25	75,76		needs to be
14.	B	33	15	45,45		further
15.	A	33	15	45,45		explored
		Materials: Viruses in Biotechnology				
16.	B	33	2	6,06		The material
17.	A	33	23	69,70		needs to be
18.	C	33	22	66,67	59,39%	further
19.	B	33	23	69,70		explored
20.	B	33	28	84,85		

Based on the assessment results presented in Table 2, students' conceptual understanding of virus materials remains low across all subtopics. The average scores were 41.28% for virus characteristics and structure, 50.30% for virus replication, 52.73% for the role of viruses, and 59.39% for the role of viruses in biotechnology. These results indicate that students' mastery of virus concepts is generally insufficient.

Regarding instructional practices, the most frequently used methods reported by teachers were lecture-based instruction (87.9%), followed by discussion (78.8%) and student presentations (45.5%). These predominantly conventional approaches provide limited support for independent, contextual, and student-centered learning, highlighting the need for more innovative instructional strategies.

All students reported the need for additional instructional materials to enhance their understanding of biology concepts. However, learning resources available at school remain limited, as most students primarily rely on printed textbooks (97%). At the same time, the use of digital learning media, such as e-modules, is still relatively low (21.2%). Notably, all students recognized the importance of smartphones as learning tools, acknowledging their potential to provide anytime, anywhere access to learning materials.

Students expressed a strong preference for visually appealing and interactive e-modules. Approximately 78.8% of students favored e-modules that include attractive images and illustrations, while 21.2% preferred interactive features such as videos and quizzes. In addition, all students indicated that e-modules should present learning materials in diverse formats, including text, images, tables, graphs, videos, and audio, to enhance comprehension. To support a clearer understanding of content organization, students also emphasized the importance of incorporating concept maps or diagrams within the e-modules (Tytenko, 2021).

In addition, most students reported that tiered practice questions, including those oriented toward Higher Order Thinking Skills (HOTS), are essential for enhancing their critical and analytical thinking abilities. The development of higher-order thinking skills is expected to support the acquisition of 21st-century skills that students are required to master. Furthermore, interactive features such as quizzes and practice exercises embedded in e-modules were perceived as highly beneficial in improving students' understanding of the learning material.

Based on these findings, the development of an e-module for virus materials is considered essential. The e-module should feature an attractive visual design, diverse and interactive content, and support for independent learning. Furthermore, it should be accessible anytime, anywhere, to provide flexible learning opportunities and to incorporate Higher Order Thinking Skills (HOTS)–oriented assessment items to enhance students' cognitive abilities. Higher-Order Thinking Skills (HOTS) assessments focus on students' ability to interpret, assess, and generate solutions to contextual and non-routine problems. They are associated with increased learning motivation and improved academic achievement (Wadana, 2017).

The next stage of the needs analysis focuses on teachers' requirements to identify the challenges they face in instructional practice, as well as the instructional needs necessary to design engaging learning experiences and select appropriate learning media. The results of

the questionnaire administered to biology teachers who are members of the Biology Teachers' Association (MGMP) of Sukoharjo Regency are presented in Table 3.

Table 3. Results of the teacher needs questionnaire regarding the need for e-modules

No.	Questions	Answer
1.	Is the classroom instructional time sufficient to deliver all biology content in accordance with the current curriculum?	Most teachers reported that the allocated instructional time was sufficient to deliver the biology content, with only a small number indicating it was insufficient.
2.	What teaching methods do you most frequently use in biology instruction?	The teaching methods applied by teachers varied, including discussions and presentations. Some teachers also implement Project-Based Learning (PjBL), Problem-Based Learning (PBL), and inquiry-based learning approaches.
3.	Do you use instructional materials when teaching biology?	All teachers reported using instructional materials in their teaching.
4.	What types of instructional materials do you use in biology lessons?	The instructional resources commonly used included textbooks, government-issued teaching modules, self-developed modules, PowerPoint presentations, student worksheets (LKPD), images, videos, e-books, YouTube, quizzes, and educational websites such as Ruang Guru.
5.	What are your reasons for using these teaching materials?	As a means to clarify and enrich the lesson material, help students understand abstract concepts, and increase interest in learning, it is tailored to the child's needs.
6.	What are the sources of learning materials you use in teaching biology?	Learning resources were obtained from various sources, including the internet, library books, educational websites, self-developed materials, and materials shared by fellow teachers.
7.	Have you integrated technology into the biology learning process?	All teachers had integrated technology into the learning process by utilizing tools such as the internet, *YouTube*, *Quizizz*, *Canva*, and *Kahoot*.
8.	If yes, what technologies do you use most frequently?	Almost all teachers reported using electronic learning materials or e-modules.
9.	In your opinion, is it necessary to use electronic learning materials such as e-modules in biology instruction?	Regarding the adequacy of current instructional materials, 6.7% of teachers stated that the materials were very adequate, 73.3% indicated that they were adequate but would be improved with additional supporting materials, and 20% reported that the materials were not yet adequate.
10.	Are the instructional materials currently used sufficient to support optimal biology learning?	73.3% of teachers stated that they had used e-modules, while 26.7% had not
11.	Do you use e-modules in biology instruction at your school?	All teachers (100%) agreed that the development of biology e-modules was necessary
12.	In your opinion, is it necessary to develop biology e-modules?	Regarding the importance of multimedia features, 80% of teachers stated that multimedia features were very important,

No.	Questions	Answer
		while 20% considered them moderately important
13.	What is your opinion regarding the use of multimedia features (such as videos, audio, and animations) in biology instructional materials?	Teachers expected e-modules to include comprehensive content, with 86.7% emphasizing the inclusion of learning materials, 80% images, 93.3% instructional videos, and 80% interactive assessment items
14.	In your opinion, what is the ideal design of an e-module to ensure ease of use for both teachers and students?	93.3% of teachers preferred interactive e-modules, while only 6.7% preferred simple PDF-based materials
15.	(Responses may include more than one option.)	All teachers (100%) agreed that e-modules should include relevant project examples or case studies
16.	What type of e-module format do you find most attractive for use in biology instruction?	Most teachers (93.3%) had implemented the Project-Based Learning (PjBL) approach, while 6.7% had not
17.	In your opinion, is it important and supportive for e-modules to provide project examples or case studies relevant to the subject matter?	60% of teachers reported experiencing difficulties in implementing PjBL, whereas 40% did not
18.	Have you ever implemented the Project-Based Learning (PjBL) approach in biology instruction?	All teachers (100%) strongly supported the development of biology e-modules based on Project-Based Learning (PjBL)
19.	Do you experience difficulties when implementing the Project-Based Learning (PjBL) approach?	100% of teachers agreed that PjBL-based e-modules should provide clear and structured project steps
20.	What is your response to the development of biology e-modules based on Project-Based Learning (PjBL) as a recommendation to support biology instruction?	93.3% of teachers said yes 6,7 % of teachers said no

Findings from the teacher needs analysis revealed that most teachers perceived the allocated instructional time as adequate. Despite this, teachers highlighted the need for effective learning media to support students' comprehension of complex topics, particularly virus-related materials. Instructional approaches frequently applied by teachers include discussion, presentations, Project-Based Learning (PjBL), Problem-Based Learning (PBL), and questioning techniques.

Most teachers reported using a variety of learning resources, including printed textbooks, government-issued modules, self-developed modules, student worksheets (LKPD), PowerPoint presentations, images, quizzes, and online media such as YouTube and educational websites. These instructional materials are used to enhance students' interest in learning and to enrich and clarify subject matter. However, 73.3% of teachers indicated that the existing instructional materials could be further improved by integrating additional learning media, while 20% reported that their current materials were still insufficient.

Most teachers (93.3%) preferred interactive e-modules that incorporate comprehensive content, images, videos, and interactive assessment items. Visual elements, including images, animations, and audio features, were considered particularly important for facilitating students' understanding of abstract concepts. Furthermore, all teachers agreed that e-modules should include relevant case studies or project-based tasks. Based on the interview results, most teachers have attempted to implement the Project-Based Learning (PjBL) approach; however, 60% reported difficulties with its implementation. Challenges mainly arise during implementation, underscoring the need for solutions to address them.

The analysis further indicates that all teachers (100%) strongly support the development of a PjBL-based biology e-module, particularly for virus materials. Teachers emphasized that such e-modules should provide clear, well-structured, and student-friendly steps for implementing the project. Additionally, 93.3% of teachers expressed the need for e-modules to include structured project report formats to support students in documenting and reflecting on their learning activities. Therefore, the development of a PjBL-based e-module is highly important and relevant for supporting meaningful, contextual learning processes and fostering students' essential 21st-century skills (Nurussalamah & Fatmaryanti, 2025).

Conclusion

Based on the needs analysis, the topic of viruses is perceived as abstract and complex, making it challenging for students to comprehend, particularly given the limited availability of interactive learning media. The learning process, which remains predominantly teacher-centered, further underscores the need for digital teaching materials that clearly and concretely visualize virus concepts. Accordingly, the development of accessible e-modules that promote active learning through a Project-Based Learning (PjBL) approach is strongly needed. Both teachers and students have expressed strong support for interactive PjBL-based e-modules enriched with multimedia features, project-based activities, and varied, tiered practice questions, including those designed to assess Higher-Order Thinking Skills (HOTS). The PjBL approach is considered particularly suitable for the virus topic because it links theoretical concepts to real-life problems, fosters active student participation, and supports contextual and meaningful learning. Therefore, developing PjBL-based e-modules on viruses holds significant potential to enhance students' conceptual understanding and improve the overall quality of the learning process.

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