E-Module Based on LI-PRO-GP Learning Model to Improve Students' Conceptual Understanding and Problem-Solving Abilities in Science Learning

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***Abstract*—Understanding concepts and solving problems is one of the essential abilities that students must master. To empower this ability, teaching materials that meet the characteristics of 21st-century learning are needed, including the electronic LI-PRO-GP learning model module. The LI-PRO-GP learning model is one of the learning models that elaborates project learning with literacy and character. Involving literacy and character components in project learning is what distinguishes this learning model from project learning models in general. This study aimed to develop a feasible, practical, and effective LI-PRO-GP learning model e-module to improve students' conceptual understanding and problem-solving skills. The research employed a Development Research method using ADDIE design framework. The research was conducted from July 2023 to September 2024 in junior high school in Malang City. The subjects of this study included four experts for the feasibility test, two teachers and 34 Grade students for the practicality test, and 27 Grade VIII students for the effectiveness test. Non-test data to assess the e-module's feasibility and practicality were collected using expert and practitioner assessment instruments. Test data for evaluating conceptual understanding and problem-solving skills were obtained through valid and reliable multiple-choice and essay questions. Descriptive analysis was used to interpret feasibility and practicality data, while paired sample t-tests were conducted to determine the e-module's effectiveness. The findings indicated that the developed LI-PRO-GP learning mdel e-module is both feasible and practical as a teaching material for vibration and wave topics. Moreover, the paired sample t-test results demonstrated that learning with the LI-PRO-GP e-module significantly improved students' conceptual understanding and problem-solving skills.**

***Keywords*—21st century skills, character building, digital teaching materials, Science literacy, science learning**

I. Introduction

Problem-solving skills are indispensable in science learning as they train students to integrate concepts, theories, and skills they have learned to solve problems. In the problem-solving process, a person must first identify and understand the problem, then develop a strategy to find a solution. This is followed by gathering relevant information or data about the issue, and finally, verifying the solution and drawing conclusions [1]. According to Suratno and Waliyanti [2] and Nalman [3] students with good problem-solving skills can explore different solutions to real problems through various interactions between problem solvers, tools, and other resources. A similar opinion was expressed by Fajarianingtyas and Hidayat [4] problem-solving skills enable students to become competent human resources and able to compete globally. In addition to the importance of this ability, other equally critical skills support it, particularly the ability to understand concepts. A solid foundation in conceptual understanding is essential for students to successfully apply their theoretical knowledge to practical problems. Students with excellent conceptual knowledge can explain physical phenomena scientifically and apply a concept naturally and contextually to solve existing problems [5]. Conceptual understanding is one of the fundamental skills that students must master before advancing to higher skills [6]. According to Romadhani and Harahap [7] Conceptual understanding is one of the most essential foundations for solving both mathematics learning problems and life difficulties.

Despite the importance of the two abilities mentioned above, field observations show that students' conceptual understanding and problem-solving skills in science learning remain relatively low. For example, research by Mahombar [8] found that students' conceptual understanding of vibration and wave material is still lacking, with the average student score falling below 70. Similarly, Widiyanto *et al.* [9] reported that students' conceptual understanding of vibration material obtained a percentage of 64%, indicating a weak level of comprehension. Research by Braca and Kalman [10] indicates that students' conceptual understanding in physics learning is still relatively low. Adam *et al.* [11] also reported that the ability to understand the concept of physics science in Malang City is relatively low. In addition to understanding the concept, similar findings suggest that the problem-solving abilities among students in Indonesia are also low. For instance, Dwi *et al*. [12] found that students' problem-solving abilities are still relatively low, as they fail to meet 3-4 problem-solving indicators. According to Ahdhianto *et al.* [13], students experience difficulties in the problem-solving process, leading to unsatisfactory assessment of their abilities. Further research by Sari *et al*. [14] showed that high school students in Malang City still struggle with problem-solving, whereas Asni *et al.* [15] emphasized

the need to imptove students' problem solving skills in the region. Additionally, Mahombar [8] and Marinda *et al.* [16] conveyed that the material on vibrations and waves is considered complicated and abstract, resulting in a lack of student interest in studying the material.

Several previous studies indicate that students' conceptual understanding and problem-solving abilities, particularly in physics topics like vibrations and waves, still need to be strengthened. One of the main factors contributing to this suboptimal ability is the traditional teacher-centered learning approach, with insufficient focus on training students in problem-solving. Research by Lubis *et al.* [17] suggest that teacher-centered learning, without innovation and supporting learning media, is a key factors in the lack of success in the learning process. Media and teaching materials help students make observations, ask questions, conduct experiments, or further observations. This finding aligns with with a survey conducted by researchers on the learning process and the use of science learning media in public and private junior high schools in Malang City. The transition from the 2013 curriculum to the independent curriculum has resulted in teachers continuing to rely on ready-made media and teaching materials from publishers, rather than creating their own. Another challange is the creation of digital teaching materials. Survey results show that 64% of teachers still use printed materials, while only 36% use digital teaching materials. The integration of technology in learning creates more interactive learning and helps students better understand the material. The presence of media is very much needed to visualize either in the form of images or videos. With media, students can observe, ask questions, find out, relate, and convey the material being studied, which enhance their understanding and problem-solving abilities [18]. Kristidhika *et al.* [19] found that the suboptimal achievement in learning is partly due to the use of less contextual teaching materials. The use of appropriate media and teaching materials can be a decisive factors in successful learning [16]. Samad and Setyabudhi [18], learning that relies solely on worksheets continuously makes students bored and less interested in learning, highlighting the need for innovation in teaching materials.

Efforts to enhance students' conceptual understanding and problem-solving abilities in science learning can be made through innovation. This innovation should introduce a new approach that helps students develop strong conceptual understanding and problem-solving abilities. One such innovation is the LI-PRO-GP learning model e-module. The LI-PRO-GP (*Literasi berbasis Proyek terintegrasi GLS dan PPK: LI-PRO-GP)* learning model is project-based approach in the School Literacy Movement (SLM), integrated with Strengthening Character Education (SCE) [20]. In its implementation, the LI-PRO-GP learning model requires students to solve contextual problems through project activities. In addition, this learning model emphasizes both scientific literacy and character development [21].

The LI-PRO-GP learning model and project-based learning both focus on addressing real-life problems that are meaningful to students. In these models, the teacher's role is to present problems, ask questions, and facilitate students in designing a project they will work on [22]. The key difference between the two models lies in the integration of the School Literacy Movement (SLM) and Strengthening Character Education (SCE). SLM is emphasized in this model through scientific literacy. For example, when the presented problems are contextual and related to scientific issues, the learning design also empowers students to develop character [20]. Meanwhile, SCE in learning aims to familiarize students with the main values of character in life. In this model, SCE is inserted at every step of learning, so when compiling learning scenarios based on project-based learning, teachers must also integrate character-building content. The goal of this approach is for students to become both knowledgeable and virtous.

Research results by Pantiwati *et al.* [21] shows that applying the LI-PRO-GP blended learning model effectively improves metacognitive abilities, critical thinking, and argumentation skills. In addition, according to Pantiwati *et al.* [23], this learning model is also effective for improving students' understanding of concepts and creativity, while Pantiwati *et al.* [24] found it effective in improving students' thinking skills. In addition to the LI-PRO-GP learning model, innovation can also involve e-modules. Research by Rusmansyah *et al.* [25] and Adawiyah and Anwar [26] indicates that e-modules are effective in increasing students' conceptual understanding. Moreover, Yanarti *et al*. [27] reported that e-modules increased conceptual understanding with an n-gain value of 62.7%. Additionally, research by Malik *et al.* [28] showed that the application of e-modules in learning contributed 81% to improving students' problem-solving abilities. Similar findings by Maksum *et al.* [29] and Suryaningtyas *et al*. [30] confirm that the implementation of e-module is effective in strengthening students' problem-solving abilities. Overall, e-modules offer a versatile learning tool that can be used in various settings, integrated with diverse elements such as images, videos, audio, text, and animation. They also provide comprehensive digital content with tests or simulations to support the learning process [31].

Based on the description provided, the components of the Li-PRO-GP learning model and electronic modules hold significant potential to promote students with independent learning and improve both conceptual understanding and problem-solving skills. The LI-PRO-GP learning model elaborates project-based learning integrated with scientific literacy and character development, aiming to produce students who are not only knowledgeable but also posses strong character. Simultaneously, the e-module serves as an independent teaching tool designed for periodic learning activities. It can be used to deepen the material that educators have delivered [32]. The LI-PRO-GP learning model can be elaborated to maximize learning with an e-module. The character-building aspect of this learning model can be inserted into the use of e-module, encouraging students to take responsibility for the implemented learning. Furthermore, science literacy within this model can be reinforced throughout the learning process by incorporating relevant components at every stage.

Despite the contributions made by both the LI-PRO-GP learning model and e-modules, there is still limited research that integrates these two components into comprenhensive

teaching materials. Therefore, it is important to conduct research that integrates the LI-PRO-GP learning model with an e-module to improve conceptual understanding and problem-solving skills in junior high school students', particularly in the topics of vibration, wave, and sound. This study aims to develop an electronic module based on the LI-PRO-GP learning model that is not only feasible and practical but also effective in improving junior high school students' conceptual understanding and problem-solving skills in these areas. The insights gained from the research can contribute to the development of new and improved learning models. This could involve the use of technology, personalized learning approaches, or other innovative methods.

II. Literature Review

A. E-Module

Electronic modules, or e-modules, are teaching or learning material systematically arranged and displayed in an electronic format, containing audio, animations and navigation features [33]. These modules serve as digital representations of independent learning materials, structured into distinct learning units. Each activity within the module is linked by navigation tools, making students more interactive with the program. E-modules often equipped with video tutorials, animations, and audio to further enrich the learning experience [34]. According to Feriyanti [35] one of the main characteristics of e-module learning materials is their capacity for independent students use. An effective-module must be arranged systematically, engaging, and clear in its presentation. Moreover, e-modules are accessible at any time and from any location, depending on student needs.

Specifically, the characteristics of e-modules align with the general qualities of learning modules, including (1) self-instructional, enabling students to learn independently; (2) self-contained, where all materials for a particular competency unit studied are incorporate in a single module, (3) stand-alone, meaning the module developed does not depend on media or need to be used with other media, (4) adaptive, with the flexibility to evolve with advancements in science and technology, (5) user friendly, ensuring ease of use and accessibility with its users, (6) consistent in the use of fonts, spacing, and layout, (7) delivered through electronic media, such as computers or smartphones, (8) multimedia, incorporating various media functions to enhance the learning experience, (9) utilizing various features available in software applications, and (10) designed with careful attention to detail [36]. Based on the explanation given, an e-module is a presentation of digital-based printed module, designed to support the implementation of learning. It represents a relevant teaching tools for independent learning, and to be effective, it must meet these specified characteristics to qualify as an e-module.

B. Li-Pro-GP Learning Model

The Li-Pro-GP learning model is a learning model developed based on project learning steps that are implemented by combining SLM activities in three stages, namely the habituation, development, and learning stages, and then integrated with SCE. Unlike project learning in general, this model combines literacy and character components in the project learning process. The literacy content in this model is expected to accustom students to literacy from an early age, especially science literacy. Science literacy in the LI-PRO-GP learning model helps students solve problems with relevant project activities. Students can provide a solution using scientific considerations, especially with the content of the project. The science literacy component presented by the educator must be appropriate to life and the context of science. This is what is emphasized in the LI-PRO-GP learning model. In addition, in the process of solving problems with project activities, the character needs to be instilled in students. Instilling character values is essential to getting used to them from an early age in students; for example, in learning, it can be integrated into project activities that involve collaborative learning.

The integration carried out from the SCE activity components includes strengthening the character of the five central character values, namely nationalism, independence, cooperation, integrity, and religiousness, which are packaged in the SCE program [23, 24, 37, 38] (Fig. 1). The role of a character in this learning is to accustom students to character from an early age, with the hope of building a competitive national civilization, building multicultural community behaviour, helping students develop into responsible and moral individuals, helping students achieve their life goals and overcoming moral crises. The Li-Pro-GP learning model can be implemented in science learning, including biology, chemistry, and physics. Several topics can be used, such as health, natural resources, environmental quality, natural disasters, and science and technology. This learning model has the main characteristic of contextual learning, which involves real-world problems at the beginning of project activities. In addition, in its implementation, this learning model also emphasizes the components of science literacy engaged in the project learning scenario.

The design of this model is integrated with character not only through literacy but also through the design of the model. This learning model requires students to be independent and construct their understanding through joint projects with group members and teachers as facilitators and motivators. The main hope of this learning model, apart from preparing students who have the abilities according to the needs of the 21st century, is also to accustom students to literacy and character. Elaborating literacy components, especially science and character literacy, as well as project activities in the LI-PRO-GP learning model, can create a complex learning atmosphere. We know that current learning requires students to be literate, which is one of the fundamental skills before having other 21st-century skills. On the learning side, it is also necessary to instill character from an early age in students so that students are not only intelligent but also have good manners. Learning scenarios must also accustom students to high-level thinking, meaning that students must contribute significantly to the process of constructing their understanding and not only receive knowledge transfer from educators. Therefore, based on several studies that have been conducted, the application of the LI-PRO-GP learning model has several advantages such as 1) empowering students to be

literate from an early age in learning, 2) instilling character from an early age to students 3) learning is more contextual with the presence of scientific literacy content, the problems presented must start from the closest problems in the students' environment, 4) in the process of completing project activities, all things conveyed by students must be disserted with scientific or scientific evidence and 5) learning becomes more complex because it involves literacy and character so that the learning output is not only intelligent students but also has character [23, 24, 38].

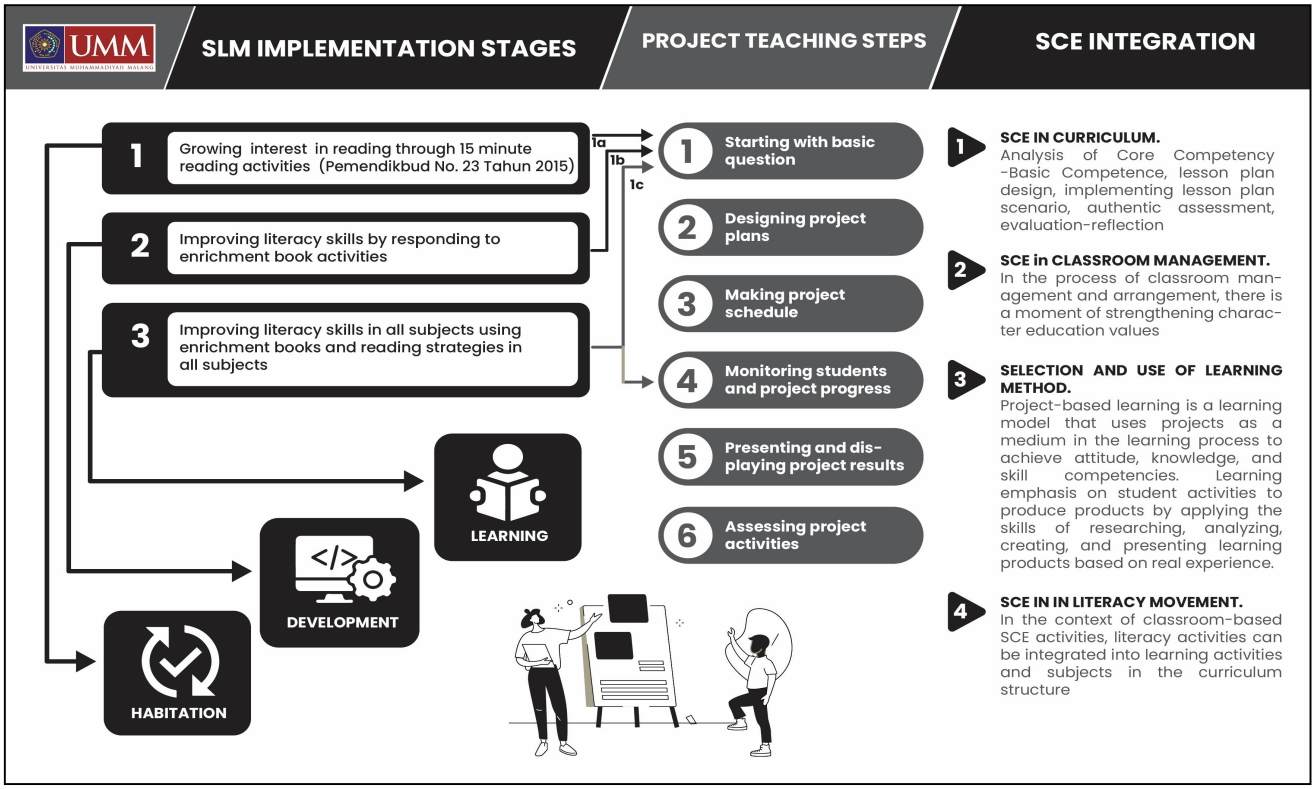


Fig. 1. Syntax LI-PRO-GP learning model.

C. *Conceptual Understanding and Problem-Solving Skills*

Conceptual understanding refers to a students's ability to explain concepts, apply them in various contexts, and derive logical consequences from their existence [39]. It represents a higher level of cognitive ability compared to merely recognizing or memorizing a concept [40]. Someone who can understand concepts can re-explain knowledge or information using their sentences according to the concepts that have been taught [41]. Additionally, as noted by Putri *et al.* [42], a good understanding of concepts also allows students to connect and apply the concepts in real situations outside the classroom, thereby improving their ability to solve problems. Consequently, developing a deep conceptual understanding is a fundamental goal in education.

Problem-solving skills are another important aspect of learning, involving the process of addressing complex challenges or questions that cannot be resolved with routine or familiar procedures [43]. These skills demand high level of intellectual engagement, requiring students to take the initiative and approach problems systematically. Applying prior knowledge, students can think critically and creatively to find solutions [44]. Moreover, the process of solving problem can build students' self-confidence, empowering students to handle similar challenges in the future [45].

D. *E-Module Li-Pro-GP Learning Model to Improve Conceptual Understanding and Problem-Solving Skills*

The Li-Pro-GP learning model e-module is an electronic module with a learning framework using the Li-Pro-GP learning syntax to improve conceptual understanding and problem-solving skills. E-module is known as one of the teaching materials that is used independently and has the characteristics of self-instructional, self-contained, stand-alone, adaptive, user-friendly [36]. To effectively improve conceptual understanding and problem-solving, a well-structured learning scenario must be intergrated into the e-module. This is achieved by incorporating the Li-Pro-GP learning model, which adapts the syntax of project-based learning and combines it with SLM and SCE frameworks [20].

Project-based learning is a learning model utilizing projects and activities as central tools for the learning process. This learning model combines project learning with scientific literacy components in SLM and SCE characters. While project-based learning serves as the foundation for the instructional steps, scientific literacy is inserted in each learning process along with the cultivation character education [46]. This model distinguishes itself from the general project-based learning by focusing on science literacy within the SLM framework. SLM is a program designed to foster literacy skills in students from an early age, both inside and outside the classroom. In the LI-PRO-GP model, scientific literacy is prioritized, emphasizing students' ability to apply scientific concepts to real-life situations. Therefore, in this learning model, components of science literacy, such as context, attitude, content, and knowledge, are inserted into

learning so that learning is truly oriented towards science literacy [20]. The ultimate goal is for students to use scientific concepts to analyze and explain phenomena in daily life and provide evidence-based explanations of these phenomena [47]. This alignment makes the model particularly suited to project-based learning, which inherently requires students to engage in discovery and experimentation. Through solving problems presented with project activities, students are encouraged to apply scientific evidence to address the phenomena and propose solutions effectively [48].

In addition to scientific literacy, character education is a key component of this learning model. This study emphasizes various character attributes, including faith, devotion to God Almighty, noble character, global diversity, mutual cooperation, independence, critical thinking, and creativity (Table 1). By involving character education, students will grow into individuals with good morals and high social responsibility and can lead society toward a better direction in the future. On a personal level, character education fosters greater responsibility in students, particularly in their learning process. This makes the integration of character education into LI-PRO-GP learning model highly compatible with e-modules. As e-modules are designed to promote independent learning, combining them with character education further enhances their effectiveness, ensuring that learning outcomes are maximized.

The LI-PRO-GP learning model, when combined with e-modules, offers students many opportunities choose topics, conduct investigations, and complete their projects. This approach allows students to gain knowledge through hands-on projects, simulating real-world scenarios that encourage the realistic creation of products and foster a sense of professionals engagement [49]. Almazroui [50] successfully solve these problems, students must thoroughly understand the concepts covered in the material, ensuring they can apply this knowledge during problem-solving process. Finally, integrating various interactive media in e-modules also increases student engagement, making learning more dynamic and preventing boredom [18]. Table 1 presents the integration of indicators of conceptual understanding and problem-solving with the LI-PRO-GP learning model supported by e-module.

Table 1. LI-PRO-GP learning scenario on e-module prototype with conceptual understanding and problem solving skills

Meeting	LI-PRO-GP learning model syntax			Concept understanding	Problem-solving
	Step	SLM	Character		
1	Starting with the big questions	a. Habituation stage b. Development stage c. Learning stage	Independent, critical thinking, and collaborative	Understanding the concept	Identify the problem
				Defining a phenomenon	Determine the cause of the problem
	Designing project activities		Independent, critical thinking, creative, and collaborative	Applying a concept	Design a solution
				Predicting a phenomenon that will be faced	Review the solution obtained
				Knowing the benefits of concepts in other fields	
	Developing a project schedule		Independent, globally diverse, critical thinking, creative, and collaborative	Applying a concept	Designing solutions
				Predicting a phenomenon that will be faced	
				Knowing the benefits of concepts in other fields	
2	Monitor project progress		Independent, globally diverse, critical thinking, creative, and collaborative	Applying a concept	Implementing problem solving solutions
				Predicting a phenomenon that will be faced	Reviewing the solutions obtained
				Knowing the benefits of concepts in other fields	
3	Presenting and displaying the results of project activities		Independent, globally diverse, critical thinking, creative, and collaborative	Applying a concept	Implementing problem solving solutions
	Assessing results and evaluation		Critical and creative thinking	Understanding the concept	Implementing problem solving solutions

III. Materials and Methods

A. Type of Research

This study employed a development research approach using the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model. The ADDIE model was chosen as it is well-suited for developing learning media due its straightforward yet systematic stages. In addition, this model incorporates evaluation at each stage, ensuring iterative improvements throughout the development process rather than limiting evaluation to the end [51]. The study focused on developing a prototype of the LI-PRO-GP learning model e-module p for vibration, wave and sound material. It was conducted between July 2023 and September 2024 in both private and public junior high schools in Malang City or Regency, East Java, Indonesia. The objective of this study were to 1) determine the feasibility of the LI-PRO-GP learning model e-module prototype in improving conceptual understanding and problem-solving abilities of class VIII students on vibration, wave and sound material in science learning, 2) determine the practicality of the LI-PRO-GP learning model e-module prototype in improving conceptual understanding and problem-solving abilities of class VIII students on vibration, wave and sound material in science learning and 3) determine the effectiveness of the LI-PRO-GP learning model e-module prototype in improving conceptual understanding and problem-solving abilities of class VIII

students on vibration, wave and sound material in science learning. The procedures of this development research followed the stages of the ADDIE model, as outlined below:

1) Analysis stage

This stage was conducted to obtain data on the needs of science learning in junior high schools in Malang City, East Java, especially regarding data on media and teaching material needs. The analysis stage involved interviews with teachers and giving questionnaires to students. This stage was completed within one month.

2) Design stage

After processing the needs analysis data, this stage involved designing the LI-PRO-GP learning model e-module. The design process included creating a storyboard for the e-module using Microsoft Word, which was then realizedinto a digital format using AndroidStudio software. Simultaneously, measurement instruments for assessing conceptual understanding and problem-solving skills were developing during this stage. The design stage was completed over three months.

3) Development stage

The development stage in this study included both feasibility and practicality testing of the e-module. The feasibility test was conducted by experts in media teaching materials, material, learning, and learning technology. Their assessment results and suggestions were used to improve the e-module. The practicality test, on the other hand, was conducted with teacher practitioners and students, whose assessments and suggestions further informed product revisions. Concurrently, the instruments for assessing conceptual understanding and problem-solving skills were reviewed by lecturer and trialed with students. This process ensured the quality and reliability of the research instrument items before their use in the effectiveness test. The development stage was completed.

4) Implementation stage

The implementation stage involved testing the effectiveness of the e-module using a quasi-experimental one-group pretest-posttest design (see Table 2). The revised e-module, deemed feasible and practical, was tested for its effectiveness in enhancing students' conceptual understanding and problem-solving skills on vibration and wave material. This stage was conducted within one month.

Description:

X1: measurement of conceptual understanding and initial problem solving abilities

Y: learning with the Li-PRO-GP learning model e-module for vibration and wave material

X2: measurement of conceptual understanding and final problem solving abilities

5) Evaluation stage

The evaluation stage was conducted throughout the entire reseravh process. It involved analyzing feedback from experts, practitioners, and the results of the effectiveness test to ensure continous improvement and validation of the e-module.

B. Research Subject

The research subjects involved in the research on the development of the LI-PRO-GP learning model e-module prototype on vibration, wave, and sound material are divided into three groups:1) subjects for the feasibility trial, 2) subjects for the practicality cobra test, and 3) subjects for the product effectiveness trial. The subjects of the feasibility trial included: 1) media and teaching materials experts, 2) material experts, 3) learning technology experts, and 4) science learning design experts. The practicality trial subjects included teacher practitioners and junior high school student practitioners in grade IX. In contrast, the subjects for the effectiveness trial are junior high school students in grade VIII.

The criteria for the subjects of the feasibility trial are 1) possess at least have a Doctoral / Ph.D qualification, 2) have expertise in learning technology for learning technology experts, 3) have expertise in physics for material experts, 3) have expertise in the curriculum design for learning experts, 4) have expertise in teaching materials for media and teaching materials experts and 5) have a minimum of five years of experience in their fields.

For the practical trial, teacher practitioners were required to have a minimum of a Bachelor's degree in Science Education and at least five years of teaching experience. Students involved in the praticality trial were Grade IX students who had previously studied vibration and wave material. Finally, the effectiveness trial subjects consisted Grade VIII junior high school students selected through a non-random sampling technique. The detailed distribution of subjects involved in the product trials is provided in Table 3.

Table 2. Effectiveness test design

Group	Pre-test	Treatment	Post-test
Experiment	X1	Y	X2

Table 3. Li-Pro-GP learning model e-module prototype product test subject

No	Subject	Information
1.	Product eligibility	a. One lecturer specializing in media and teaching materials from the Biology Education Department, University of Muhammadiyah Malang. b. One lecturer specializing in material from the Faculty of Engineering, University of Muhammadiyah Malang. c. One lecturer specializing in learning technology from the Biology Education Department, University of Muhammadiyah Malang. d. One lecturer specializing in learning design from the Biology Education Department, University of Muhammadiyah Malang
2.	Practicality of the product	Two science teachers: one from Junior High School 13 Malang and one from Madrasah Tsanawiyah Muhammadiyah 1 Malang. 34 Grade IX Students of junior high school 13 Malang
3.	Product effectiveness	27 Grade VIII students of Madrasah Tsanawiyah 1 Muhammadiyah Malang for the effectiveness trial.

The subjects of the practicality and effectiveness tests of the LI-PRO-GP learning model e-module in this study involved junior high school students. Based on the Research Ethics guidelines concerning children, when conducting research with children who are still minors, several things must be considered, such as ethical guidelines for involving children in research [52]. In this study, the children involved were informed openly of the purpose of the study, and the class teacher conveyed this information. The class teacher also conveyed a roadmap of the research implementation that would be carried out in the class so that students knew the research activities that would be carried out in the future. In addition to conveying it openly in class, the teacher also conveyed it in writing in the class group and asked students to communicate this to their parents. At the next meeting, the teacher asked for feedback from students regarding the availability of permission to carry out research, both personally and consent from parents. In addition, this study did not change students' learning activities because the research was carried out according to the schedule of each class, so it was like learning in general.

C. Data Collection Techniques and Research Instruments

The data collection techniques employed in this study involved both tests and non-tests. The non-test data consisted of expert assessments, specifically from 1) media and teaching materials experts, 2) material experts, 3) learning technology experts, and 4) science learning design experts. These assessments aimed to determine the feasibility of the LI-PRO-GP learning model e-module prototype concerning vibration, wave, and sound materials. Additionally, practicality assessments were conducted by practitioners, namely junior high school science teachers and grade IX students. The instruments utilized to gather data on feasibility and practicality were expert and practitioner assessment sheets that employed a Likert scale ranging from 1 to 5, where (1) represents "very poor," (2) indicates "poor," (3) signifies "sufficient," (4) stands for "reasonable," and (5) denotes "very good".

In terms of test data, this study focused on assessing conceptual understanding and problem-solving skills. The non-test data stemmed from the expert and practitioner assessments regarding the LI-PRO-GP learning model e-module prototype applied to the materials on vibration, waves, and sound. The data related to conceptual understanding were obtained through 15 multiple-choice questions, which scored 1 point for a correct answer and 0 points for an incorrect one. The conceptual understanding instrument employed in this study had undergone limited trials, resulting in valid and reliable questions. Prior to the trial, lecturers from the University of Muhammadiyah Malang reviewed the instruments pertaining to conceptual understanding and problem-solving. The instrument trial at Junior High School 13 Malang involved 34 grade IX students. The analysis of question validity utilized the Pearson product-moment correlation, guided by the decision-making criteria based on r count and r table values or significance values. A question item was considered valid if r count was greater than r table; conversely, it was deemed invalid if r count was less than r table. Regarding the significance value, a question item was valid if the sig value was less than 0.05; it was invalid if the sig value was greater than 0.05. For this study, a significance level of 0.05 was adopted, with the formula df = n-2 (where n = 34), yielding a value of 0.2869.

Of the 15 items assessing conceptual understanding, all 15 were found to be valid (see Table 4). Following the validity assessment, a reliability test was conducted, which evaluated the instrument's reliability using Cronbach's alpha. According to [53], a good instrument demonstrates reliability above 0.7. The reliability of the conceptual understanding instrument yielded a value of 0.879, indicating high reliability (see Table 5). Data regarding problem-solving abilities were obtained using five essay questions, with scoring ranging from 0 to 4. The problem-solving instrument was also reviewed by a lecturer, and limited trials were carried out to ensure the validity and reliability of the question items. Five question items concerning problem-solving abilities were determined to be valid (see Table 4). The reliability of the problem-solving instrument was similarly assessed using Cronbach's alpha, resulting in a value of 0.875, also indicating high reliability (see Table 5). The quality analysis of the instrument items for this study was performed using SPSS 27 software.

Table 4. Validity of research instruments

Instruments	Item	Rcount Value	Sig value	Description
Concept understanding	Item 1	0.642	0.000	Valid
	Item 2	0.481	0.004	Valid
	Item 3	0.710	0.000	Valid
	Item 4	0.577	0.000	Valid
	Item 5	0.675	0.000	Valid
	Item 6	0.476	0.004	Valid
	Item 7	0.906	0.001	Valid
	Item 8	0.933	0.000	Valid
	Item 9	0.531	0.000	Valid
	Item 10	0.431	0.011	Valid
	Item 11	0.351	0.042	Valid
	Item 12	0.474	0.005	Valid
	Item 13	0.581	0.001	Valid
	Item 14	0.735	0.001	Valid
	Item 15	0.615	0.001	Valid
Problem solving	Item 1	0.496	0.003	Valid
	Item 2	0.866	0.000	Valid
	Item 3	0.892	0.000	Valid
	Item 4	0.871	0.000	Valid
	Item 5	0.892	0.000	Valid

Table 5. Reliability of research instruments

Instruments	Item	Cronbach's Alpha value	Degree of Reliability
Concept understanding	Item 1	0.870	High
	Item 2	0.876	High
	Item 3	0.866	High
	Item 4	0.873	High
	Item 5	0.869	High
	Item 6	0.881	High
	Item 7	0.852	High
	Item 8	0.851	High
	Item 9	0.874	High
	Item 10	0.878	High
	Item 11	0.887	High
	Item 12	0.876	High
	Item 13	0.872	High
	Item 14	0.865	High
	Item 15	0.872	High
Problem	Item 1	0.908	High

solving	Item 2	0.831	High
	Item 3	0.821	High
	Item 4	0.830	High
	Item 5	0.821	High

D. Data Analysis Techniques

The feasibility and practicality assessments of the LI-PRO-GP learning model e-module prototype, specifically related to vibration and wave materials, were analyzed using descriptive quantitative methods to ascertain the quality of the product (see Table 6). Additionally, the measurement results pertaining to conceptual understanding and problem-solving abilities were analyzed descriptively. The effectiveness of the learning model was evaluated using a paired sample t-test, facilitated by IBM SPSS 27. A prerequisite for this analysis is the normality test, which determines whether the data follows a normal distribution. If the significance value exceeds 0.05, it indicates that the data is normally distributed; conversely, if the significance value is less than 0.05, the data is deemed not normally distributed. Should the data be normally distributed, the analysis may proceed with the paired sample t-test. The decision-making criteria for the paired sample t-test are outlined in Table 7.

Table 6. Product quality interpretation

Percentage of achievement	Product visibility	Practical product
76%–100%	Very decent	Very practical
56%–75%	Decent	Practical
26%–55%	Less decent	Less practical
0%–25%	Not decent	Not practical

Table 7. Research hypothesis

Hypothesis	Decision	Ability
Concept understanding	Significance value < 0.05	There is a significant difference between the average pre-test and post-test scores of students' conceptual understanding resulting from the application of the LI-PRO-GP learning model e-module on vibration and wave material.
	Significance value > 0.05	The average pre-test and post-test scores for students' conceptual understanding in the context of the LI-PRO-GP learning model e-module applied to vibration and wave material are the same.
Problem solving	Significance value < 0.05	The average pre-test and post-test scores of students' problem-solving skills differ following the application of the LI-PRO-GP learning model e-module on vibration and wave material.
	Significance value > 0.05	The average pre-test and post-test scores of students' problem-solving skills resulting from the application of the LI-PRO-GP learning model e-module to vibration and wave material are the same.

IV. Result and Discussion

A. Result

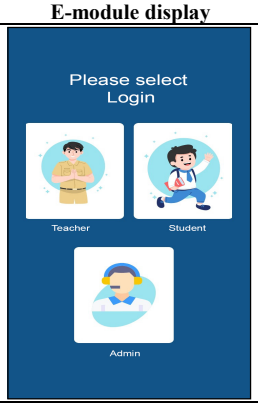
1) Analysis stage: Analysis of e-module needs in learning

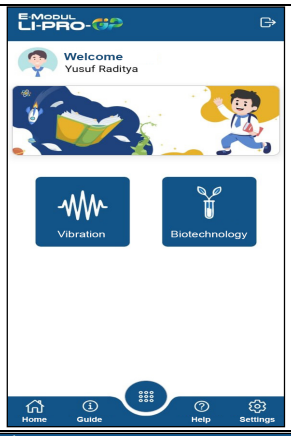
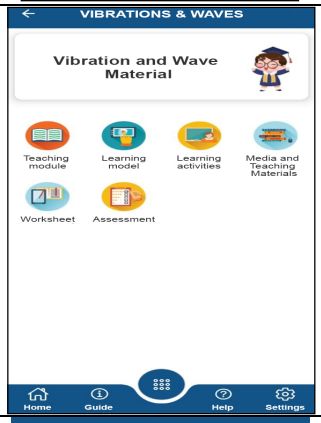
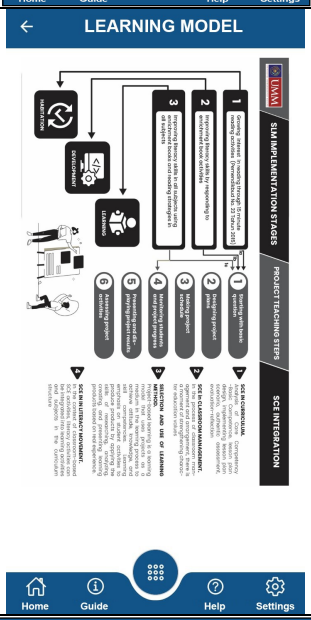
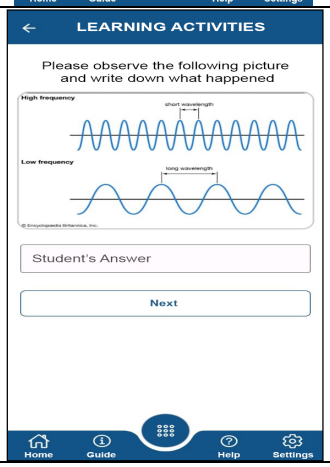
During the analysis stage of this study, it was determined that the use of media and teaching materials in science learning in Malang City has been implemented within an independent curriculum for some time. Supportive materials, including electronic teaching resources, are essential for effectively executing this independent curriculum. The findings from field analysis indicate that the majority of Junior High Schools in Malang City (66%) continue to rely primarily on printed teaching materials. Interviews with teachers corroborate these findings, highlighting the challenges faced in acquiring technology-based teaching resources, particularly in terms of time and technical expertise, especially as schools adjust to the Independent Curriculum. Science learning necessitates interactive media that can assist in conveying complex concepts, providing contextual examples, and encouraging students to learn independently, with teachers acting as facilitators or motivators. A pressing need has been identified for media and teaching materials that are integrated with technology. Furthermore, in addition to the findings related to media and science teaching materials in Malang City, prior literature suggests that there is a need to enhance junior high school students' conceptual understanding and problem-solving skills in science learning, particularly in physics topics such as vibrations, waves, and sound.

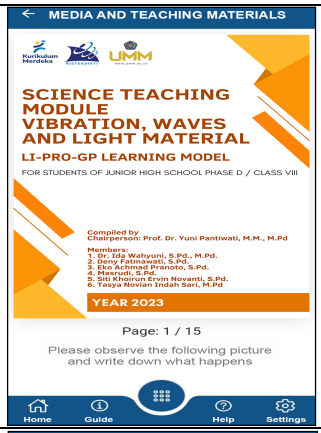
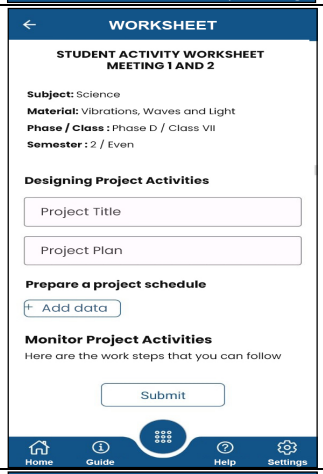
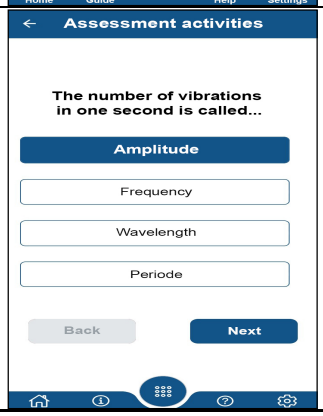
2) Design stage: Design of the LI-PRO-GP learning model e-module prototype

The prototype e-module of the LI-PRO-GP learning model was developed specifically for the vibration, wave, and sound curriculum aimed at grade VIII junior high school students. The learning activities within the prototype e-module were designed to enhance students' conceptual understanding and problem-solving abilities (see Table 8). The first meeting of the LI-PRO-GP learning model prototype e-module was created using Android Studio software and the JavaScript programming language, allowing it to be operated on Android smartphones.

Table 8. Prototype design of LI-PRO-GP learning model e-module

E-module display	Component	Description
	Enter the e-module prototype	When entering the LI-PRO-GP learning model e-module prototype, the initial display presents options for Teacher, Student, and Admin, along with their respective IDs and passwords.

	Front view of the e-module prototype	After logging into the e-module prototype, students will find several materials available for study.
	The main menu of the e-module prototype on the subject of vibrations and waves	The next stage involves accessing the main menu after selecting one of the materials to be explored within the e-module prototype. The main menu includes teaching modules, learning models, learning activities, media and teaching materials, worksheets, and assessments.
	LI-PRO-GP learning model	This menu provides a syntax of the learning model implemented in the LI-PRO-GP learning model e-module prototype.
	Learning Activities	This menu contains learning activities that are aligned with the steps of the LI-PRO-GP learning model. In this section, students have the opportunity to interact with peers and teachers while utilizing the e-module.

	Media and teaching materials	This menu offers various media and teaching materials that are used in conjunction with the LI-PRO-GP learning model e-module prototype.
	Worksheet	This menu features worksheets that students can use while learning with the LI-PRO-GP learning model e-module prototype.
	Evaluation	This menu includes assessments employed in the LI-PRO-GP learning process. Assessments can be conducted directly; for instance, cognitive assessments consisting of multiple-choice questions allow students to complete them within the e-module and receive results and discussions afterward.

3) Development stage: Development of the LI-PRO-GP learning model e-module prototype

The development stage of the LI-PRO-GP learning model e-module prototype for vibration and wave material involved assessing the product with several experts to determine its feasibility, followed by practitioner assessments. The experts in this study comprised lecturers from relevant fields at the University of Muhammadiyah Malang. The outcomes of the expert assessments were utilized to consider improvements to the e-module product. According to the evaluation results presented in Table 9, the media and teaching materials experts reported that each assessed aspect received ratings of "decent" and "very decent" for various elements of the LI-PRO-GP learning model e-module product. Furthermore, the assessment of the feasibility of the vibration and wave material within the LI-PRO-GP learning model e-module product yielded decent ratings across all elements.

Table 9. Results of the feasibility assessment of the LI-PRO-GP learning model e-module prototype

Experts	Aspect	Average Experts Assessment Results	Category
Media and teaching materials expert	Initial view of the e-module prototype	76%	Very decent
	Contents of the e-module prototype	72%	Decent
	Presentation of the e-module prototype	73%	Decent
Subject matter expert	Depth and breadth of material	68%	Decent
	Presentation of material	70%	Decent
	Presentation of e-module prototype	73%	Decent
Learning technology expert	Rationality	70%	Very decent
	User friendly	80%	Very decent
	User interface	80%	Decent

	Characteristics of e-module prototype	75%	Very decent
Learning design expert	Formulation of indicators and learning objectives	76%	Very decent
	Selection of teaching materials	68%	Very decent
	Selection of learning models	80%	Very decent
	Selection of sources. media and learning materials	70%	Decent
	Suitability of learning	80%	Very decent
	Assessment	76%	Very decent
	Language	80%	Very decent

Additionally, the evaluation conducted by learning technology experts indicated that each aspect of the LI-PRO-GP learning model e-module product received "decent" and "very decent" ratings in several categories. The assessment of the learning design feasibility for the LI-PRO-GP learning model e-module product also reflected that each element received ratings of "decent" and "very decent" in multiple areas. Beyond the feasibility assessment results, experts provided several suggestions and feedback to enhance the quality of the product before it underwent field trials. Once the necessary improvements were made, the product was further assessed by practitioners, including science teachers and students.

The results of the practicality assessment of using the LI-PRO-GP learning model e-module prototype product by the Teacher on the aspect learning, material, language and display (Table 10). At the same time the evaluation of the product's practicality by students obtained a practical value in the elements of ease of display, ease of use,and attractiveness of the display (Table 10). Apart from the assessment results. there were several suggestions and input from the Teacher and Participants to improve the product so that the product developed is practical as a teaching material for vibration and wave material to enhance the ability to understand concepts and solve problems.

Table 10. Results of the practicality assessment of the LI-PRO-GP learning model e-module prototype product

Practitioner	Aspect	Average Practicality Assessment Results	Category
Teacher	Learning aspects	81%	Very practical
	Material aspects	74%	Practical
	Language aspects	80%	Very practical
	Display aspects	80%	Very practical
Student	Display ease aspects	73%	Practical
	Use ease aspects	74%	Practical
	Display attractiveness aspects	75%	Practical

4) Implementation stage: Implementation of learning with the LI-PRO-GP learning model e-module prototype

The application of learning with the LI-PRO-GP learning model e-module prototype aims to determine the use of the LI-PRO-GP learning model e-module prototype in improving students' conceptual understanding and problem-solving abilities in vibration, wave and sound materials in science learning. The effectiveness trial stage was carried out on 27 students of class VIII Madrasah tsanawiyah Muhammadiyah 1 Malang City. The results of descriptive data analysis of students' conceptual understanding abilities show that there is an average difference or an increase in the values before and after treatment (Table 11 and Fig. 2). In detail, the pre-test data for conceptual understanding obtained an average value of 66, a minimum value of 64, a maximum value of 69, a range of values 5 and a standard deviation of 1.7. In the post-test data, an average value of 84, a minimum value of 83, a maximum value of 89, a range of values 4, and a standard deviation of 1.5 was obtained.

Furthermore, the results of the descriptive analysis of the pre-test and post-test scores of students' problem-solving abilities show that there is a difference in the average pre-test and post-test scores or an increase in the scores before and after treatment (Table 11 and Fig. 2). In detail, the pre-test data on problem-solving abilities obtained an average score of 59, a minimum score of 57, a maximum score of 62, a range of scores of 5 and a standard deviation of 2.1. In the post-test data, the average score was 83, a minimum score of 80, a maximum score of 86, a range of scores of 6, and a standard deviation of 4.1.

Table 11. Descriptive statistics data of concept understanding and problem solving

Ability	Data	Range	Minimum value	Maximum value	Average	Standar Deviasi
Conceptual understanding	Pre-test	5	64	69	66	1.7
	Post-test	4	83	89	84	1.5
Problem solving	Pre-test	5	57	62	59	2.1
	Post-test	6	80	86	83	4.1

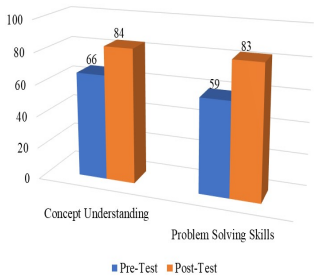


Fig. 2. Average results of pre-test and post-test.

The normality test results for the pre-test scores of conceptual understanding, analyzed using the Kolmogorov-Smirnov test, indicated a significance value greater than 0.05 (sig value > 0.05), meaning that the pre-test data of students' conceptual understanding was normally distributed. In comparison, the normality test for the post-test scores of students' conceptual understanding yielded a sig value of 0.086, which is also greater than 0.05 (Table 12). Moreover, the normality test results for the pre-test scores of

problem-solving ability showed a sig value of 0.200, again greater than 0.05, indicating that these data were normally distributed as well. Similarly, the normality test results for the post-test scores of problem-solving ability obtained a sig value of 0.96, confirming that the post-test data were also normally distributed. Because both the data on problem-solving ability and conceptual understanding ability were found to be normally distributed, further analysis was conducted using paired sample t-tests (see Table 12).

The results of the paired sample t-test for students' conceptual understanding indicated a significance value of 0.000, which is less than 0.05 (Table 13). This finding implies a statistically significant difference between the average pre-test and post-test scores of students' conceptual understanding who participated in learning using the LI-PRO-GP learning model e-module prototype. The results of this statistical test are also supported by the observable difference in the average pre-test and post-test values, as illustrated in Fig. 2.

Table 12. Normality test results

Ability		Statistic	df	Sig.
Conceptual Understanding	Pre	0.161	27	0.072
	Post	0.157	27	0.086
Problem Solving	Pre	0.137	27	0.200*
	Post	0.155	27	0.096

Table 13. Paired sample T-Test results of conceptual understanding ability

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre - Post	−18.62963	1.49739	0.28817	−19.22198	−18.03728	−64.648	26	0.000

The results of the paired sample t-test for students' problem-solving abilities similarly yielded a significance value of 0.000, indicating a significant difference between the average pre-test and post-test problem-solving scores of students who engaged with the LI-PRO-GP learning model e-module prototype (Table 14). The outcomes of this statistical test are further substantiated by the observed differences in the average pre-test and post-test scores, as presented in Fig. 1.

Table 14. Paired sample T-Test results of problem solving ability

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre - Post	−24.14815	2.99620	.57662	−25.33340	−22.96289	−41.879	26	0.000

5) Evaluation stage: Evaluation of the development of the LI-PRO-GP learning model e-module prototype

The final stage is the evaluation stage, during which various improvements will be made throughout the product development process. In small group trials aimed at developing the LI-PRO-GP learning model e-module prototype to enhance conceptual understanding and problem-solving, the evaluation process is conducted by both experts and practitioners. The subsequent evaluation stage occurs during the large group trial phase, which is intended to assess the effectiveness of the LI-PRO-GP learning model e-module prototype in improving students' conceptual understanding and problem-solving skills.

B. Discussion

1) Feasibility and practicality of the LI-PRO-GP learning model e-module prototype

The LI-PRO-GP learning model e-module is an electronic teaching material that students can access on their smartphones. This e-module is specifically designed for junior high school students in grade VIII who are studying vibration, wave, and sound material. The LI-PRO-GP learning model e-module on this content is structured for three instructional sessions, accompanied by several supporting features presented within the e-module (see Table 1). This module has been developed to empower students' conceptual understanding and problem-solving skills; each syntax of the LI-PRO-GP learning model is designed to foster the development of these abilities based on specific indicators (see Table 1).

In the process of developing learning products, including the LI-PRO-GP learning model e-module, several quality requirements must be addressed to ensure that the product is suitable for use in the learning process. According to Haryadi and Nurmala [54], the teaching materials developed for the learning process should be feasible, practical, and effective. The study results presented in Table 9 indicate that the feasibility assessment of the LI-PRO-GP learning model e-module received favorable results as evaluated by media and teaching materials experts, material experts, learning technology experts, and learning design experts. Furthermore, the findings of studies conducted by Triwoelandari *et al.* [55] and Asriani *et al.* [56] align with the conclusion that e-modules are suitable for use as teaching materials in science learning. Additionally, research by Rusmansyah *et al.* [25] and Asih *et al.* [57] supports the assertion that e-modules are effective materials for enhancing students' conceptual understanding and problem-solving skills. According to Purnomo and Wilujeng [58], the results of the expert assessments serve to evaluate the product and ascertain its feasibility based on the relevant aspects of the teaching materials. This phase is critical in the development process, as it aims to minimize the potential for misconceptions. Following the assessment of feasibility, the practicality of the product is evaluated. The results presented in Table 10 indicate that the practicality assessment conducted for both teachers and students yielded favorable outcomes,

demonstrating that the LI-PRO-GP learning model e-module is practical for use as teaching material for vibration, wave, and sound topics, thereby enhancing conceptual understanding and problem-solving abilities. Research findings by Warodiah *et al.* [59] reveal that the practicality assessment approached 100%, indicating increasingly positive responses from both educators and students towards the learning materials. According to Bumantara *et al.* [60], the results of the practicality assessment of the learning product indicate that teachers require support in implementing the product. Furthermore, both teachers and students, as field practitioners, did not encounter difficulties in using and engaging with the learning process facilitated by the LI-PRO-GP learning model e-module. This suggests that both teachers and students can effectively follow the learning flow established by the LI-PRO-GP learning model presented in the e-module. However, during the development of the LI-PRO-GP learning model e-module, practitioners provided several suggestions that have been incorporated into the product development process.

2) Effectiveness of the LI-PRO-GP learning model e-module prototype to improve conceptual understanding and problem-solving

The results of the study indicated that both descriptively and statistically, the application of the LI-PRO-GP learning model e-module significantly influenced students' conceptual understanding abilities (see Table 13). These findings are consistent with the results reported by Kurnia *et al.* [61], which indicate that the use of e-modules enhances students' conceptual understanding. Additional research conducted by Lestari *et el.* [62] and Lestari *et el*. [63] confirms that the implementation of e-modules in learning contributes positively to improving students' conceptual understanding. According to Kurnia *et al.* [61], learning with e-modules allows students to grasp the material in a more straightforward manner. By utilizing e-module learning resources, students can deepen their understanding of concepts and find the material more engaging, especially when the e-module is integrated with an appropriate learning model. Research by Pantiwati *et al.* [24] and Sari *et al.* [38], further demonstrates that the LI-PRO-GP learning model effectively enhances students' conceptual understanding and cognitive skills.

The LI-PRO-GP learning model e-module successfully improves students' conceptual understanding, particularly regarding the understanding indicators. For instance, in the conceptual understanding indicator, students are required to comprehend the concepts being taught so that they can subsequently apply this knowledge to real-world situations. By utilizing the LI-PRO-GP learning model e-module, students are guided by their peers to address challenges through project-based activities, which culminate in the creation of a product. This approach invites students to actively participate in the learning process. Moreover, the LI-PRO-GP learning scenarios integrated into the e-module are also designed to foster character development in students. Each scenario incorporates elements of scientific literacy, which further empowers students' conceptual understanding. Consequently, the LI-PRO-GP learning model e-module not only enhances comprehension but also promotes literacy and character development among students.

In addition to fostering conceptual understanding, the study results in Table 13 reveal that the application of the LI-PRO-GP learning model e-module positively affects students' problem-solving abilities. This finding aligns with the research conducted by Hasanah *et al.* [64], which demonstrated that the implementation of the flipped classroom e-module positively influences students' problem-solving skills. Furthermore, Ningrum and Rohim [65] found that applying e-modules to junior high school students had a beneficial effect on their problem-solving abilities. Additionally, research by Mahendra *et al.* [66] indicates that e-modules also positively impact students' problem-solving skills. According to Hasanah *et al.* [64], integrating technology through e-modules that blend technological resources and learning experiences offers new opportunities for engaging and interactive teaching and learning, making the process more appealing to students.

Problem-solving skills encompass the ability to identify and comprehend a problem, devise effective strategies, organize information, make informed decisions, and execute plans to resolve the challenges faced [67]. The LI-PRO-GP learning model e-module effectively enhances problem-solving skills, as it aligns well with the model's instructional framework. Presenting contextual problems at the onset of the learning process and encouraging students to engage in discussions with their peers to address these problems is a key strategy for promoting the identification and resolution of challenges. Moreover, these contextual problems are often related to significant issues at local, national, or global levels, thereby enhancing relevance. The collaborative learning design inherent in the LI-PRO-GP learning model e-module also serves to cultivate character development in students, such as cooperation and independence during group activities. The user-friendly features of the LI-PRO-GP e-module facilitate student learning by providing accessible learning menus.

In general, the research and development results of the LI-PRO-GP learning model e-module are feasible, practical, and effective in improving the ability to understand concepts and solve the problems of junior high school students with the material of vibrations and waves. Besides the research results, the LI-PRO-GP learning model e-module was developed using vibrations, waves, and light. The selection of this topic is based on the results of the needs analysis at school. However, it does not rule out the possibility that the LI-PRO-GP learning model e-module can be developed on other science materials that are suitable and by the characteristics of the LI-PRO-GP learning model. The results of this study and several previous studies show that applying the LI-PRO-GP learning model in learning has a positive impact. It can create an interactive learning environment and equip students with literacy and character.

In addition to being limited to material, the development research results also show that electronic teaching materials, namely the LI-PRO-GP learning model e-module, are effective in improving the ability to understand concepts and solve problems. Although it was effective, the trial of the effectiveness of the LI-PRO-GP learning model e-module was conducted without a control group, or the prosecution

was only performed on one experimental group due to the limited research sample. The selection of the experimental group in the LI-PRO-GP learning model, the e-module effectiveness test, also has a significant role for the class teacher. The class teacher is a practitioner who knows the characteristics of students during the learning process, so he also has a role in selecting the sample. Therefore, further research can involve a control group based on this study. Applying the LI-PRO-GP learning model e-module on vibration, wave, and light material effectively improves the ability to understand concepts and solve problems in the experimental group. Thus, in further research, the effectiveness of the LI-PRO-GP learning model e-module between the experimental and control groups can be more comprehensive and reliable.

V. Conclusion

The results of this study indicate that the LI-PRO-GP learning model e-module is a feasible teaching material for enhancing students' conceptual understanding and problem-solving abilities in the areas of vibrations, waves, and light. The feasibility assessment has been validated by evaluations conducted by media and teaching materials experts, material experts, learning technology experts, and learning design experts. In addition to being feasible, the LI-PRO-GP learning model e-module product has also been found to be practical for use in learning, as indicated by the assessment results from both teachers and students. Moreover, the effectiveness testing revealed significant differences in students' conceptual understanding and problem-solving abilities before and after utilizing the LI-PRO-GP learning model e-module. The paired t-test supports the observed average differences in pre-test and post-test scores, confirming a notable enhancement in both conceptual understanding and problem-solving abilities. The findings from this study demonstrate that the LI-PRO-GP learning model e-module contributes positively to the field of education, particularly in learning technology, and is effective in improving students' conceptual understanding and problem-solving capabilities. This e-module is compatible with all Android smartphones, allowing teachers and students to engage in learning activities both inside and outside the classroom. Teachers can monitor distance learning activities via the e-module, while students can report their progress in independent learning endeavors. Although this research focused on vibration and wave materials, future studies can expand its application to broader scientific content. Additionally, it is important to note that this study conducted product trials in small groups without a control group. Thus, future research should consider applying this product on a larger scale, potentially incorporating a comparison group to enhance the comprehensiveness of the findings. Finally, the effectiveness test of this e-module demonstrated statistical significance at an alpha level of 5%. Therefore, in future research, it may be valuable to explore other alpha levels beyond the traditional 5%.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Creating concept of article based upon research findings and supervising all activities, from manuscript writing to publication (Yuni Pantiwati); Editing manuscript and review (Aminudin); Converting design and concept of article into manuscript (Lud Waluyo); Analyzing research data (Fandy Hardian Permana); Designing article and writing manuscript based on fixed design and concept (Tasya Novian Indah Sari); and Converting design and concept of article into manuscript (Endrik Nurrohman). All authors had approved the final version.

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