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The development of e-module optical physics instruments based on Creative Problem Solving (CPS) for improving high school students' digital literacy

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Abstract: The accelerating development of digital technology has shaped a rapidly evolving information landscape, significantly impacting the realm of education. The integration of digital technology in education necessitates a positive outlook and a strong digital literacy. This study aims to develop a creative problem-solving-based e-module as a learning media to enhance the digital literacy of students in the subject of optics-related physics. The research adopts a Research and Development (R&D) approach and employs the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model for development. Data collection tools in this study include observation sheets, expert validation sheets, student response questionnaires, and digital literacy tests. The data analysis combines qualitative and quantitative techniques, including a t-test. The findings of this research indicate that the utilization of e-modules based on CPS only succeeded in enhancing the indicators of communication skills through digital media and the responsible and positive use of digital media, among all the digital literacy indicators.
Keywords: e-modul; creative problem solving; digital literacy

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Introduction

Digital technology has become a powerful tool for solving problems in various fields, including education. The rapid advancement of digital technology has significantly transformed the educational landscape and opened up various creative opportunities in the classroom (Voňková, 2019; Alt, 2020). Furthermore, digital technology also holds great potential in enhancing the learning experience (Jamalai, 2021). However, the use of digital technology in education necessitates a positive outlook and strong digital literacy from the Students (Alakrash, 2021). Digital technology has shaped the dynamics of information, communication, and collaboration (Albó, 2019; Alt, 2020), thus requiring Students to delve into, consider, comprehend, and critically assess every piece of information (Chou, 2019). Given the increasing adoption of digital technology by educators in recent decades, it is evident that digital literacy has garnered significant attention and a crucial role in society (Audrin, 2023). Therefore, Students require digital literacy competencies to be able to acquire, process, evaluate, create, and effectively communicate information.

The tool or digital technology that has seen significant development in its utility for learning is the mobile phone. Once regarded solely as a communication device, mobile phones have now transformed into multifunctional tools that support education. Mobile phones enable Students to actively access information and learning materials instantly (Kacetl, 2019). Furthermore, mobile phones also facilitate distance learning (Silva, 2021), online collaboration (Torous, 2019), and various interactive learning applications (Sari, 2019). Mobile-based learning through phones has been widely disseminated and successfully enhanced Students' flexibility in constructing knowledge (Nami, 2020). One issue that arises is the use of mobile phones, which sometimes divert Students' attention away from the learning materials. In this case, Students tend to focus more on the entertainment offered by their phones rather than the study materials (Romero-Rodríguez, 2020). This leads to a lack of concentration among Students in seeking alternative solutions to solve physics problems (Mushroor, 2020; Min, 2021). To address this challenge, it is crucial to integrate digital literacy into education. Digital literacy can positively contribute to the learning environment because the higher the digital literacy, the more positive the impact of mobile phone usage (Taskin, 2022).

The key to integrating technology such as mobile phones while developing digital literacy skills lies in creativity. Digital literacy is defined as the ability to access, manage, comprehend, integrate, communicate, appreciate, and create information safely and appropriately through digital technology (UNESCO, 2018). In practice, digital literacy will encourage Students to create and generate knowledge, and this necessitates creativity (Voňková, 2019). The integration of digital literacy and creativity in technology can be achieved by designing problem-solving learning experiences (Alt, 2020). This will empower Students to skillfully address various real-world problems using digital tools (Alt, 2020). Therefore, it is important to choose a learning model that encourages Students to think "out of the box" and develop creative solutions to overcome challenges. The Creative Problem Solving (CPS) model can be a solution. The CPS model aims to prepare Students with a deep understanding and stimulate their creativity in generating innovative solutions to challenges (Chou, 2019; Maielfi, 2021). CPS creates a framework for Students to explore data by generating and addressing issues (Van Hooijdonk, 2023). Students can identify key information that helps them set the main direction for problem-solving efforts (Van Hooijdonk, 2023).

The subject of Physics is highly suitable for applying the CPS model. Physics is the most fundamental science with complexities identical to problem-solving (Puspitasari, 2021; Rahayu, 2022). Physics learning often involves contextual problems (Satriawan, 2020). Physics education requires a model that can assist Students in actively developing thinking skills to solve problems (Satriawan, 2020). Additionally, incorporating digital literacy as a structured learning mechanism within physics can simplify, facilitate, and strengthen the learning process and outcomes (Sukarno, 2020). Digital literacy will help Students adapt to the digital environment while supporting their creativity in generating creative ideas (Van Laar, 2020). The practice of digital literacy in physics learning typically encompasses a variety of textual content, images, graphics, sounds, symbols, colors, and layouts (Gu, 2023). Digital literacy practices can also involve creating/storing learning notes, documenting interactions, downloading instructional videos, and conducting literature reviews to identify and categorize online information (Gu, 2023).

Digital learning media is essential to assist Students in improving their digital literacy. Digital learning media can enhance the effectiveness and efficiency of education (Pahlawan, 2021) while delivering comprehensive content (Solong, 2021). One of the familiar digital learning media used is the e-module (electronic module). An e-module is a learning material with complete interactive components that allow Students to study independently (Maielfi, 2021). E-modules can integrate technology (Reddy, 2020) and package learning content that is relevant, consistent, and sufficient for Students' activities and capabilities (Annisha, 2020; Saripudin, 2022). E-modules can stimulate Students' curiosity (Syafril, 2021), subsequently encouraging their direct involvement in various learning activities (Aarsand, 2019). Therefore, e-modules are suitable for various levels of education and subjects, including physics (Haruna, 2021; Baihaqi, 2022). Furthermore, e-modules can be developed using various approaches, one of which is the Creative Problem Solving (CPS) model. CPS is a problem-solving-oriented learning model that promotes creativity development (Beda, 2020). E-modules based on CPS in physics education are highly suitable for training Students to find creative solutions to problems using digital technology (Dewi, 2019). Incorporating knowledge such as Internet-related terms into CPS-based e-modules will increase the chances of developing Students' digital literacy (Ali, 2023). Therefore, CPS-based e-modules will provide strong motivation for Students to solve problems using their digital literacy (Raichel & Alt, 2020).

Based on the overview above, this study will focus on the development of instructional media in the form of CPS-based e-modules. The aim of this study is to examine the development of CPS-based e-modules related to the topic of optical instruments in physics for high school students, with the goal of enhancing the digital literacy of the students.

Method

This research adopts the research and development model known as ADDIE, as proposed by Robert Maribe Branch in 2009. The ADDIE model encompasses five key phases: Analysis, Design, Development, Implementation, and Evaluation. In this study, the focus was on developing a Computer-Based Learning Module (CPS-based e-module). The analysis phase entailed an initial assessment that covered subject matter concepts, learner characteristics, curriculum, and learning objectives. In the design phase, the development of the product commenced. Following that, in the development phase, an initial product was created, and data collection instruments were tested for their feasibility through assessments conducted by experts in the fields of media, subject matter, and practitioners/educators, as well as limited field trials. The assessments by the experts were computed using the average score formula, with the criteria and percentage of expert assessments presented in Table 1. The data from the limited field trials were analyzed using the Quest and Parscale programs.

The implementation phase involved field testing using a pre-experimental design known as the One-Group Pretest-Posttest Design, as depicted in Figure 1. The One-Group Pretest-Posttest Design is a research approach in which only one group of subjects is observed, and measurements are taken at two points in time: before the treatment (pretest) and after the treatment (posttest), as described by Sugiyono in 2017.

$$O1 \times O2$$

Figure 1. Research Design

It is known that $O1$ represents the pretest results before the treatment, $\times$ signifies the treatment in the form of students learning using CPS-based e-modules, and $O2$ denotes the posttest results after the treatment.

This research was conducted at MAN 3 Yogyakarta, in the 11th-grade class of the Mathematics and Natural Sciences (MIPA) program. The data collection techniques used in this research included student response questionnaires, observation sheets, and digital literacy tests. The student response questionnaire consisted of 10 positive statements with four answer choices, where 4 meant strongly agree, 3 meant agree, 2 meant disagree, and 1 meant strongly disagree. The questionnaires were administered after the students had studied using the CPS-based e-module product. Subsequently, a digital literacy test consisting of 12 items was used to obtain data on the students' digital literacy skills. This test was in the form of multiple-choice questions with five answer choices given at the beginning and end of the learning process. Meanwhile, the observation sheet focused on assessing students' digital literacy skills based on digital literacy indicators. The observation sheet was used when observing students who were using the CPS-based e-module product in their learning.

At the end of the evaluation phase, an assessment of the product's effectiveness was conducted. The assessment was based on the results of the digital literacy test and questionnaires capturing the students' feedback after using the CPS-based e-module. The data from the test results were processed using SPSS version 23.0 software and analyzed using the t-test and Cohen's d or Cohen's Effect Size (d), calculated using Equation 1 (Cohen, 2013).

$$d = \frac{\bar{x} \text{ the } posttest\ result - \bar{x} \text{ the pretest result}}{\text{Combined standard deviation } (S_P)} \quad (1)$$

Meanwhile, the results of observations and student feedback questionnaires were calculated using the average score formula in Equation 2, and the percentage criteria for both are presented (Daryanes, 2023) in Table 1.

$$\%\ score = \frac{Score\ obtained}{Total\ score} \times 100\% \tag{2}$$

Table 1. The criteria for the percentage of questionnaire scores and observation sheets

Percentage (%)	Criteria
$86 < \text{score} \leq 100$	Very well/Strongly agree
$76 < \text{score} \leq 85$	Well/Agree
$60 < \text{score} \leq 75$	Enough
$55 < \text{score} \leq 59$	Not Enough /Disagree
≤ 54	Less Once/Totally Disagree

Results and Discussion

Results

This research is focused on the development of an e-module optical physics instruments based on Creative Problem Solving (CPS) to enhance the digital literacy of students in the topic of optical instruments using the ADDIE model. Each stage of the development is presented in a clear diagram as shown in Figure 2.

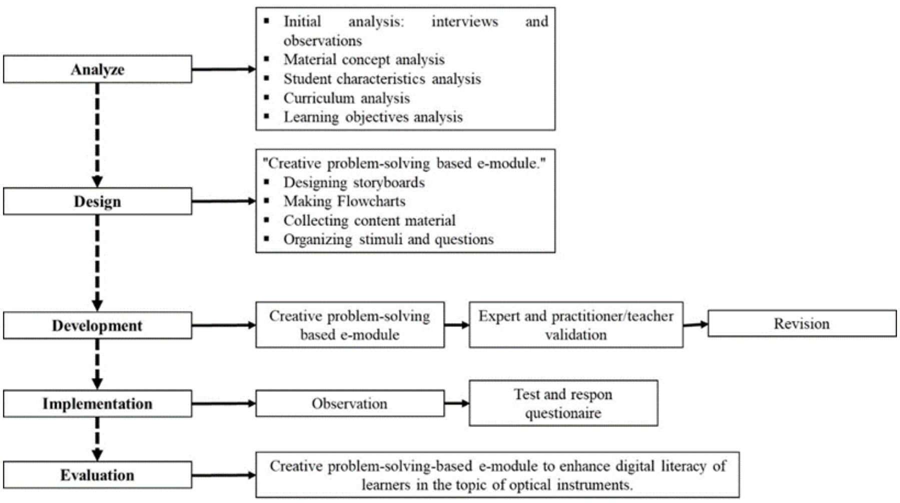

Figure 2. Flowchart of CPS-Based E-Module Development

The first stage in the development process involves conducting initial analysis of the subject matter, participant characteristics, curriculum, and learning objectives. The analysis of learning objectives and the concept of optical tools in the Physics subject is presented in Table 12. Subsequently, initial analysis and student characteristics are assessed through interviews with teachers and observations of activities both inside and outside the learning environment. One of the obstacles encountered is that students tend to underutilize technology during their learning process. Instead, the use of mobile phones by students distracts their attention. As a result, students become less focused in seeking alternative solutions to solve the physics problems they face. Therefore, there is a need for an improvement in digital literacy through digital learning media that can encourage students to explore and utilize technology.

So far, digital learning media used by physics teachers include non-interactive e-modules, PowerPoint, and PhET simulations. Therefore, there is currently no Creative Problem Solving (CPS)-

based e-module for optical instruments. Hence, the development of a CPS-based e-module is considered necessary, as it can serve as a solution to enhance concentration and digital exploration to aid in problem-solving in physics education.

Table 2. Concept Material Analysis

Basic Competencies	Analyzing the operation of optical instruments using the properties of light reflection and refraction by mirrors and lenses.
Subject Matter	Optical Instruments
Sub-topics	The eye and the formation process of images in the eye. Eye defects and eyeglasses. Camera and the image formation process in a camera. Lup and the image formation process in a lup. Magnification in lup.
Indicators	Explaining the natural optical instrument of the eye, including its components and functions. Describing the process of image formation in ocular optics. Identifying various types of eye defects. Applying the principles of geometric optics equations to solve problems related to ocular optics. Elaborating on the image formation process in cameras and lup. Applying geometric optics equations to address issues related to cameras and lup.
Media	Creative Problem Solving (CPS)-Based e-module
Time Allocation	Face-to-Face Meeting Time 2 × 45 minutes Assignment Structure & Self-Directed Learning 2 × 60 minutes

The next stage involves designing a CPS-Based e-module to enhance the digital literacy of Students. The CPS-Based e-module is developed based on the entire analysis phase's outcomes. The design of the CPS-Based Creative Problem Solving (CPS) e-module is carried out in this stage, which includes:

1. The first slide should contain a login page with a 'Start' button to initiate the module.
2. The home slide includes main menus such as an introduction, learning activity 1, learning activity 2, learning activity 3, quiz 1, quiz 2, glossary, and bibliography.
3. The introduction menu includes an introduction, an e-module overview and content, user instructions and learning guidelines, learning objectives, concept maps, and material choices.
4. The learning activity menu contains learning activities that Students must follow based on the CPS learning model. These activities are complemented by stimuli such as illustrations and short stories, prompting questions, material discussions, and sample questions.
5. The quiz menu includes tests that must be completed at the beginning and end of the learning process. Each test consists of 6 essay questions related to the material that Students must solve and 6 multiple-choice questions related to digital literacy.
6. The glossary and bibliography menu contains explanations of symbols and terms related to the material and digital literacy, as well as references that Students can search for or access through the internet.

Each slide will be equipped with a menu containing instructions, active navigation buttons, and animations.

The next stage is the development phase, a continuation of the CPS-based e-module product design, consisting of the following three stages:

1. Pre-production

In the pre-production stage, preparations are made for various software required to develop the CPS-based e-module, namely Ms. Word, PowerPoint, Google Forms, Typeform, and Flip PDF Professional/Flip Builder. Additionally, the downloading of icons, material images, and animations necessary for inclusion in the product is carried out.

2. Production

During the production stage, the design is integrated into the CPS-based e-module, and the e-module is created. The CPS-based e-module is equipped with various operational features, including illustrations and animated characters. The development results of the product can be seen in Figure 3.

Figure 3. Development of CPS-Based E-Module Learning Media

3. Post-Production

In the post-production stage, after the CPS-based e-module has been created, an inspection is carried out to ensure that all navigation buttons are active and functioning properly. Additionally, a thorough review is conducted on the presented illustrations, completeness of the material, image and animation quality, as well as the accuracy of answer keys in sample questions and tests. Once the inspection is complete, the product is then published in the form of an accessible internet link.

The CPS-based e-module product that has been developed was subsequently evaluated and validated by three experts, namely a subject matter expert, a media expert, and a practitioner/teacher. The validation results by the experts can be seen in Figure 4.

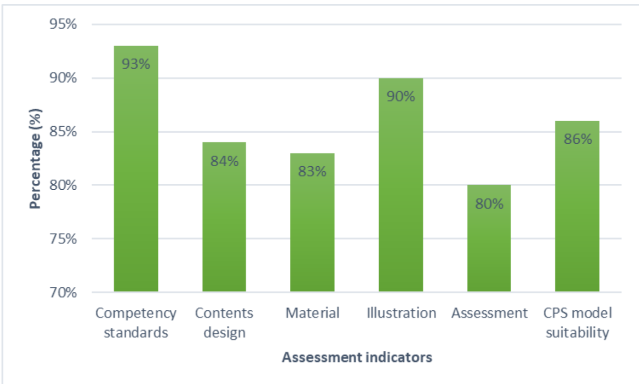

Figure 4. Results of Media Expert and Practitioner/Teacher Validation

Based on the validation results conducted on the CPS-based e-module product by experts and practitioners/teachers, considering six main indicator aspects, namely competency standards, content design, material, illustrations, assessment, and CPS model alignment. According to the media suitability criteria in Table 3, five aspects of the product are classified as excellent, while one aspect, which is the assessment, is considered good.

Table 3. Media Feasibility Category

Percentage (%)	Criteria
$81 < \text{score} \leq 100$	Very good
$61 < \text{score} \leq 80$	Good
$41 < \text{score} \leq 60$	Enough
$21 < \text{score} \leq 40$	Not good
$0 < \text{score} \leq 20$	Not very good

The CPS-based e-module product was revised following feedback from experts and practitioners, particularly focusing on areas requiring improvement in test questions and the addition of sample questions and practice exercises.

The next phase involves the implementation to assess the effectiveness of the CPS-based e-module product on students' digital literacy. The sample for the field test comprised 24 students from the 11th-grade science class at MAN 3 Yogyakarta. During the implementation phase, observations were made on the students, taking into account digital literacy indicators developed based on the UNESCO framework, as presented in Table 4. Subsequently, a questionnaire gathering students' feedback on the CPS-based e-module product was administered after the learning process, as shown in Table 5.

Table 4. The observation sheet during the learning process using CPS-based e-modules

No.	Statement	Student activity	Score
1	The capability to utilize Information and Communication Technology (ICT) tools to support tasks.	Students do not employ anything to elucidate the concept.	0
		Students utilize various features to elucidate the concept clearly.	1
		Students employ various features and images to elucidate the concept clearly.	2
		Students employ various features, images, and graphs to elucidate the concept clearly.	3
2	The capability to discover and organize digital data, as well as critically evaluate information.	Students only use existing information.	0
		Students search for digital information sources.	1
		Students seek information sources and evaluate the relevance of the information.	2
		Students search for digital information sources, evaluate the reliability and relevance of the information.	3
3	The capability to communicate effectively through digital media.	Students do not participate in discussion forums.	0
		Students participate in direct discussion forums.	1
		Students participate in online and offline discussion forums and express their opinions.	2
		Students participate in online and offline discussion forums and express their opinions and ideas.	3
4	The capability to employ digital resources to address problems and challenges.	Students do not formulate solution plans.	0
		Students formulate solution plans that yield correct but incomplete answers solely from the available textbooks.	1
		Students formulate solution plans that yield correct but incomplete answers from credible information sources.	2
		Students create comprehensive solution plans and produce correct answers from credible information sources.	3

No.	Statement	Student activity	Score
5	The capability in using digital sources for learning.	Students do not create presentations using online learning tools.	0
		Students create presentations using online learning tools based on the content from textbooks.	1
		Students create presentations using online learning tools by utilizing less credible information sources.	2
		Students create presentations using online learning tools by leveraging credible information sources.	3
6	The capability to use digital media positively and responsibly.	Students do not generate positive and informative posts.	0
		Students generate positive posts but lack informativeness.	1
		Students generate positive and informative posts.	2
		Students create positive and informative posts that promote ethical and secure messaging.	3

Table 5. Questionnaire on Student Feedback regarding CPS-based e-Modules

No.	Statement	Student Answer Choices			
		1	2	3	4
1	This physics module has made me more enthusiastic about exploring physics.				
2	The presentation of this physics module is engaging.				
3	This physics module has supported me in mastering physics lessons, especially optical instrument materials.				
4	The delivery of the content in this physics module is related to everyday life.				
5	The materials presented in this module are easy for me to understand.				
6	The presentation of the materials in this physics module encourages me to discuss with other peers.				
7	The use of illustrations can provide motivation for learning the materials and utilizing the internet.				
8	This physics module encourages me to write down what I have understood in the "Reflection" column.				
9	This module includes evaluation tests that can assess the depth of my understanding of optical instrument materials.				
10	The language used in this physics module is simple and easily understood.				

The observation was conducted during the e-module learning process based on CPS (Creative Problem Solving) and according to the digital literacy indicators presented in Figure 5.

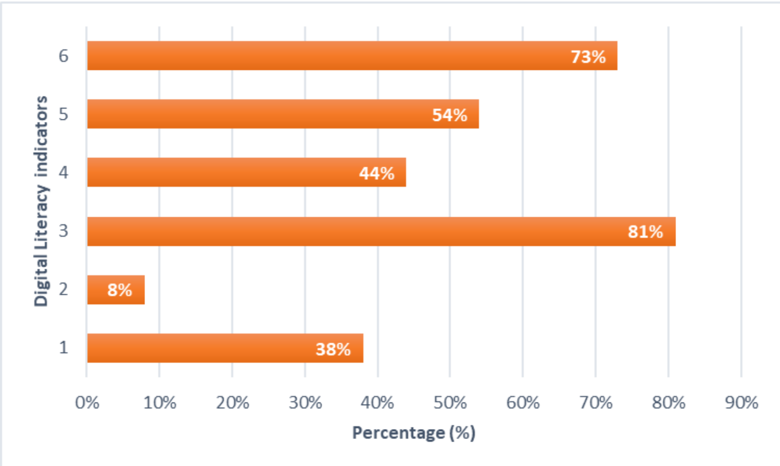

Figure 5. The results of observing students when using CPS-based e-modules

Based on Figure 5, it can be observed that the digital literacy indicators have achieved the highest percentage, specifically 81%, falling into the "good" category, with one indicator in the "satisfactory" category. Through our observations, it is evident that when students utilize CPS-based e-modules, they can clearly express their ideas, thoughts, and information obtained from the internet, such as text and images.

The digital literacy indicator showing the lowest percentage achievement in Figure 5 is 8%, categorized as "not very good." Our observations suggest that students tend to accept information uncritically, without critical consideration. Moreover, not all students possess strong search skills in selecting and using appropriate keywords. Furthermore, the remaining three digital literacy indicators also fall into the "not very good" category. Based on our observations, the most fundamental factor in digital learning is slow or unstable internet connectivity. Some classrooms in the school have weak signals or slow internet access, causing students difficulty in accessing the internet and e-modules. This situation diminishes students' motivation to explore digital resources or deepen their understanding of technology. Essentially, students tend to use only basic technology for daily purposes without experimenting with more advanced features or tools.

In this context, learners also conducted an evaluation of the CPS-based e-module by completing a questionnaire to capture their feedback on the e-module. Based on Figure 6, there are five statements that received positive feedback from the learners and fall into the "agree" category, while five statements fall into the "somewhat agree" category. In question number 2, which pertains to the appearance of the e-module, the highest feedback was obtained with a percentage of 82%, indicating a strong consensus. The CPS-based e-module incorporates various elements to make the presentation of the material more engaging. The term "appearance" of the e-module refers to how information and learning materials are presented to the learners. Therefore, collaboratively integrating various elements into the instructional media will enhance the learners' motivation during the learning process (Tan, 2019).

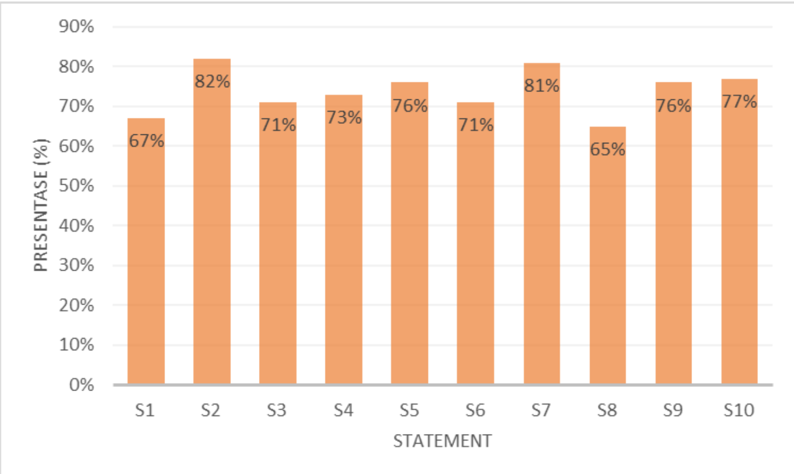

Figure 6. Students' Response to Creative Problem Solving (CPS)-Based E-module

Hypothesis testing is conducted to ascertain the influence of CPS-based E-Module, as shown in Table 6. Meanwhile, the impact of the E-Module is calculated using equation (1) to determine the extent of the CPS-based E-Module's impact on students' digital literacy. The results of the calculation in equation (1) yield the Cohen's Effect Size (d) value, which is subsequently categorized based on Table 7.

Table 6. The Final Hypothesis of CPS-Based E-Module to Enhance Students' Digital Literacy

Hipotesis	t_{hitung}	t_{tabel}	Sig	α
H_0 : There is no significant influence of the Creative Problem Solving (CPS)-Based E-Module on students' digital literacy. H_1: There is significant influence of the Creative Problem Solving (CPS)-Based E-Module on students' digital literacy.	1.807	2.069	0.084	.05
Explanation	$t_{hitung} < t_{tabel}$		Sig > α	
Result			H_0 Accepted, H_1 Rejected	

Table 7. Interpretation of Effect Size based on Cohen's d calculation (Cohen, 2013)

Nilai d	Interpretasi
$0{,}2 - 0{,}5$	Small Effect
$0{,}51 - 0{,}8$	Moderate Effect
$> 0{,}8$	Large Effect

In the final stage of evaluation, it was conducted based on the results of field tests in classes that had utilized CPS-based e-modules. The evaluation format can be enhanced by integrating various types of media, such as videos and simulations. This is done in an effort to improve digital literacy indicators, given that many of these indicators still fall into the low category.

Discussion

The Creative Problem Solving (CPS) based E-module is an electronic module designed for physics learning based on the Creative Problem Solving (CPS) learning model. This E-module encompasses materials that encourage participants to think creatively and develop their ability to find innovative solutions to problems they face by utilizing the internet or technology. Based on the results of testing during the implementation phase, the CPS-based E-module is still insufficient in providing a significant impact on improving the digital literacy of students. The impact of using the CPS-based E-module on digital literacy is assessed with an effect size of 0.36893883. Based on Table 5, it is evident that the CPS-based E-module falls into the category of a small effect. This means that the CPS-based E-module does not bring about a significant influence on the enhancement of the digital literacy of students. However, the CPS-based E-module has an attractive interface that successfully captures the attention of the students. This, though, is not sufficient to stimulate the motivation and interest of the students, which, in turn, affects their ability to explore information for problem-solving (Sukmadewi, 2023). As a result, students merely follow what is readily available in the E-module without attempting to delve deeper into information. Meanwhile, the digital literacy of students can improve if they make an effort to search for and identify key information that can guide them in problem-solving (Van Hooijdonk, 2023). Additionally, the most significant challenge that arises when using the CPS-based E-module during learning is the sudden weakening of the signal. Factors such as internet disruptions or signal interruptions have become familiar constraints in the integration of technology in schools (Kerkhoff, 2022).

The subsequent observation results provide an important report regarding the impact of CPS-based modules on the enhancement of digital literacy among students during their learning process. The observed outcomes that have been studied can offer an effectiveness report of the product during the testing phase (Nasreen, 2022). The observations report the students' achievement in each literacy indicator during the learning activities using e-modules. Based on the observations, out of the six digital literacy indicators, students only managed to achieve good and satisfactory ratings for two indicators, namely, the ability to communicate through digital media and the responsible and positive use of digital media. The indicator for students' communication skills through digital means significantly outperforms the other digital literacy indicators. During classroom learning, students tend to engage in traditional or face-to-face communication more frequently. However, it is evident that students have become accustomed to digital communication, which has become a part of their daily lives, with almost no geographical or time limitations (Santos, 2019). Students who can communicate digitally can interact effectively and flexibly, enhancing their learning capabilities (Johanson, 2022). Digital communication interaction refers to the use of applications such as Zoom (Katz, 2021), WhatsApp (Urien, 2019), Telegram (Shabani, 2022), and Instagram (Yuen, 2023). Students using these applications can communicate through both oral and written means (Johanson, 2022). They can also share various types of content, such as documents, text, and videos (Johanson, 2022). Nevertheless, the success of CPS is heavily influenced by students' willingness, ability, and active participation (Treffinger, 2023). When discussion sessions are used to gather opinions, CPS has its limitations and cannot guarantee the success of students in improving their digital literacy (Fauziah, 2020). This is because discussions can be dominated by active students, while passive students may prefer to follow their peers' instructions (Fauziah, 2020). Therefore, even if students' communication skills are far superior, it may not necessarily help improve the success of e-module CPS in enhancing other digital literacy indicators.

Furthermore, the indicator of digital literacy related to the ability to use digital media positively and responsibly has been successfully achieved by a majority of students. The current generation of students is individuals who have mastered digital technology and are at least aware of the responsibility to use digital media positively (Gudmundsdottir, 2020), such as maintaining the privacy of their social media accounts (Tifferet, 2019). However, students still require support because not all of them fully understand the significant responsibility involved in the use of digital media (Gudmundsdottir, 2020; Greenhow, 2020). However, four other indicators of digital literacy do not seem to receive positive impacts from CPS-based e-modules. These digital literacy indicators include the ability to use ICT devices, the ability to find and organize digital data, the utilization of digital resources for learning purposes, and the ability to solve digital-related problems. In other words, the use of CPS-based e-modules does not significantly influence the improvement of students' digital literacy. Nevertheless, CPS has developed responses to enhance students' thinking processes (Rubenstein, 2019) in organizing creative ideas (Beda, 2020; Rahayu, 2022). CPS-based e-modules that allow students to interact with interactive text or images presented are not sufficient to enhance students' digital literacy. This is because to develop digital literacy, students should practice practical skills in using software and hardware (Suwarto, 2022). Practical skills encompass operational, information navigation, social, and creative skills (Polizzi, 2020).

Conclusion

Conclusion and suggestions are required. The conclusion contains a summary of the research result and discussion. It is research findings to answer the research questions or objectives. Suggestions consist of recommendations from the author to further researchers or advice to use this research result. This research has resulted in a product in the form of a CPS-based e-module for enhancing the digital literacy of physics students, specifically focusing on optical instruments. The development of the CPS-based e-module went through the stages of Analysis, Design, and Development. Based on the evaluations conducted by three validators, including subject matter experts, media experts, and practitioners/teachers, the developed product was assessed across six main indicators: competency standards, content design, material, illustrations, assessment, and compatibility with the CPS model. Five aspects of the product were rated as very good, while the assessment aspect received a good rating.

However, based on the implementation of the product, it did not have a significant impact on improving the digital literacy of the students. The students' feedback on the product was mostly categorized as average, except for the product's appearance, which received positive feedback from the students. The limitations of this study include the fact that the product has not been tested for its effectiveness on a larger scale, necessitating further research. Furthermore, the developed product is limited to the topic of optical instruments in physics, and it faces technical issues related to internet connectivity. Recommendations for future researchers include testing CPS-based e-modules in larger classes to assess their effectiveness in enhancing students' digital literacy and expanding the product to include more interactions between digital technology and information mobility..

References

Aarsand, P. (2019). Categorization activities in norwegian preschools: digital tools in identifying, articulating, and assessing. *Frontiers in psychology, 10*, 973.

Alakrash, H. M. (2021). Technology-based language learning: Investigation of digital technology and digital literacy. *Sustainability, 13*(21), 12304.

Albó, L. H.-L. (2019). Smartphones or laptops in the collaborative classroom? A study of video-based learning in higher education. *Behaviour & Information Technology, 38*(6), 637-649.

Ali, A. R. (2023). Validated digital literacy measures for populations with low levels of internet experiences. *Development Engineering, 8*, 100107. doi:https://doi.org/10.1016/j.deveng.2023.100107

Alt, D. &. (2020). Enhancing perceived digital literacy skills and creative self-concept through gamified learning environments: Insights from a longitudinal study. *International Journal of Educational Research, 101*, 101561. doi:https://doi.org/10.1016/j.ijer.2020.101561

Audrin, C. &. (2023). Key factors in digital literacy in learning and education: a systematic literature review using text mining. *Education and Information Technologies, 27*(6), 7395-7419.

Baihaqi, H. K. (2022). Development of Physics E-book Based on Technological Pedagogical Content Knowledge (TPACK) on Thermodynamic Laws Topic. *Jurnal Pendidikan Fisika Indonesia, 18*(1), 67-74. doi: https://doi.org/10.15294/jpfi.v18i1.28924

Beda, Z. S. (2020). Creativity on demand–Hacking into creative problem solving. *NeuroImage, 216*, 116867. doi:https://doi.org/10.1016/j.neuroimage.2020.116867

Chou, S. F. (2019). Effect of creative problem-solving teaching on the sustainable service innovation literacy of undergraduate hospitality students. *Journal of Hospitality, Leisure, Sport & Tourism Education, 24*, 190-201. doi:https://doi.org/10.1016/j.jhlste.2019.03.004

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences* (11 ed.). London: Academic press.

Daryanes, F. D. (2023). The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon, 9*(4), e15082. doi:https://doi.org/10.1016/j.heliyon.2023.e15082

Dewi, G. A. (2019). The needs analysis on module development based on creative problem solving method to improve students' problem solving ability. *Journal of Physics: Conference Series. 1153*, p. 012129. IOP Publishing.

Fauziah, M. M. (2020). The Effect of Thinking Actively in a Social Context and Creative Problemsolving Learning Models on Divergent-Thinking Skills Viewed from Adversity Quotient. *European Journal of Educational Research, 9*(2), 537-568.

Greenhow, C. &. (2020). Social distancing meet social media: digital tools for connecting students, teachers, and citizens in an emergency. *Information and Learning Sciences, 121*(5/6), 341-352.

Gu, M. M. (2023). Investigating university students' digital citizenship development through the lens of digital literacy practice: A Translingual and transemiotizing perspective. *Linguistics and Education, 77*, 101226. doi:https://doi.org/10.1016/j.linged.2023.101226

Gudmundsdottir, G. B. (2020). Student teachers' responsible use of ICT: Examining two samples in Spain and Norway. *Computers & Education, 152*, 103877. doi:https://doi.org/10.1016/j.compedu.2020.103877

Haruna, H. Z. (2021). Improving instruction and sexual health literacy with serious games and gamification interventions: an outlook to students' learning outcomes and gender differences. *Interactive Learning Environments*, 1-19. doi:https://doi.org/10.1080/10494820.2021.1888754

Jamalai, M. &. (2021). Fostering 21st century skills using an online discussion forum in an English for specific purpose course. *Malaysian Journal of Learning and Instruction, 18*(1), 219-240.

Johanson, L. B. (2022). Competence in Digital Interaction and Communication—A Study of First-Year Preservice Teachers' Competence in Digital Interaction and Communication at the Start of Their Teacher Education. *The Teacher Educator, 58*(3), 270-288. doi:https://doi.org/10.1080/08878730.2022.2122095

Kacetl, J. &. (2019). Use of smartphone applications in english language learning—A challenge for foreign language education. *Education Sciences, 9*(3), 179.

Katz, A. &.-Y. (2021). From classrooms to zoom rooms: Preserving effective communication in distance education. *Journal of Information Technology Case and Application Research, 23*(3), 173-212. doi:https://doi.org/10.1080/15228053.2021.1922248

Kerkhoff, S. N. (2022). Professional development on digital literacy and transformative teaching in a low-income country: A case study of rural Kenya. *Reading Research Quarterly, 57*(1), 287-305. doi: https://doi.org/10.1002/rrq.392

Maielfi, D. (2021). Need Analysis for Physics E-Module Based on Creative Problem Solving Integrated 21st Century Skills. *Journal of Physics: Conference Series. 1940*, p. 012110. IOP Publishing.

Min, H. J. (2021). Development of a smartphone-based lateral-flow imaging system using machine-learning classifiers for detection of Salmonella spp. *Journal of Microbiological Methods, 188*, 106288. doi:https://doi.org/10.1016/j.mimet.2021.106288

Mushroor, S. H. (2020). The impact of smart phones and mobile devices on human health and life. *International Journal of Community Medicine and Public Health, 1*, 9-15. doi:http://dx.doi.org/10.18203/2394-6040.ijcmph20195825

Nami, F. (2020). Educational smartphone apps for language learning in higher education: Students' choices and perceptions. *Australasian Journal of Educational Technology, 36*(4), 82-95.

Nasreen, S. C. (2022). Effectiveness of COVID-19 vaccines against symptomatic SARS-CoV-2 infection and severe outcomes with variants of concern in Ontario. *Nature microbiology, 7*(3), 379–385. doi:https://doi.org/10.1038/s41564-021-01053-0

Pahlawan, R. I. (2021). Developing an Interactive Digital Handout for Momentum and Impulse Material Physics in High Schools. *Journal of Education Technology, 5*(1), 137-144.

Polizzi, G. (2020). Digital literacy and the national curriculum for England: Learning from how the experts engage with and evaluate online content. *Computers & Education, 152*, 103859. doi:https://doi.org/10.1016/j.compedu.2020.103859

Puspitasari, R. &. (2021). Conditions of learning physics and students' understanding of the concept of motion during the covid-19 pandemic. *Journal of Physics: Conference Series* (p. 012045). IOP Publishing.

Rahayu, S. S. (2022). The Effectiveness of Creative Problem Solving-Flipped Classroom for Enhancing Students' Creative Thinking Skills of Online Physics Educational Learning. *Jurnal Pendidikan IPA Indonesia, 11*(4).

Raichel, N., & Alt, D. (2020). Enhancing perceived digital literacy skills and creative self-concept through gamified learning environments: Insights from a longitudinal study. *International Journal of Educational Research, 101*, 101561. doi:https://doi.org/10.1016/j.ijer.2020.101561

Reddy, P. S. (2020). Digital literacy: A review of literature. *International Journal of Technoethics (IJT), 11*(2), 65-94. doi:10.4018/IJT.20200701.oa1

Romero-Rodríguez, J. M.-D.-M.-C.-J. (2020). Impact of problematic smartphone use and Instagram use intensity on self-esteem with university students from physical education. *International Journal of Environmental Research and Public Health, 17*(12), 4336.

Rubenstein, L. D. (2019). Students' strategic planning and strategy use during creative problem solving: The importance of perspective-taking. *Thinking Skills and Creativity, 34*, 100556. doi:https://doi.org/10.1016/j.tsc.2019.02.004

Santos, H. B. (2019). Digital transformation in higher education: the use of communication technologies by students. *Procedia Computer Science, 164*, 123-130. doi:https://doi.org/10.1016/j.procs.2019.12.163

Sari, A. C. (2019). Interactive gamification learning media application for blind children using android smartphone in Indonesia. *Procedia Computer Science, 157*, 589-595.

Satriawan, M. R. (2020). Physics learning based contextual problems to enhance students' creative thinking skills in fluid topic. *Journal of Physics: Conference Series* (p. 022036). IOP Publishing.

Shabani, A. &. (2022). Media literacy and the credibility evaluation of social media information: Students' use of Instagram, WhatsApp and Telegram. *Global Knowledge, Memory and Communication, 71*(6/7), 413-431. doi:https://doi.org/10.1108/GKMC-02-2021-0029

Silva, P. G. (2021). istance learning during social seclusion by COVID-19: improving the quality of life of undergraduate dentistry students. *European Journal of Dental Education, 25*(1), 124-134.

Solong, N. P. (2021). Manajemen Pembelajaran Luring dan Daring Dalam Pencapaian Kompetensi. *Tadbir: Jurnal Manajemen Pendidikan Islam, 9*(1), 19-32. doi:https://doi.org/10.30603/tjmpi.v9i1.2064

Sugiyono. (2017). *Metode penelitian kuantitatif, kualitatif, dan R&D.* ALFABETA.

Sukarno, S. &. (2020). The Effect of Students Metacognition and Digital Literacy in Virtual Lectures During the Covid-19 Pandemic on Achievement in the Methods and Strategies on Physics Learning. *Jurnal Pendidikan IPA Indonesia, 9*(4), 477-488.

Sukmadewi, A. G. (2023). Development of Mobile Learning Based E-Module to Improve Concept Understanding and Interest Learning X Class Student in Momentum and Impulse. *Jurnal Penelitian Pendidikan IPA, 9*(8), 5914-5920.

Suwarto, D. H. (2022). Developing digital literacy practices in Yogyakarta elementary schools. *Electronic Journal of e-Learning, 20*(2), 101-111.

Syafril, S. L. (2021). Hybrid learning on problem-solving abiities in physics learning: A literature review. *Journal of Physics: Conference Series*, *1796*, p. 012021. doi:10.1088/1742-6596/1796/1/012021

Tan, H. C. (2019). Using a structured collaborative learning approach in a case-based management accounting course. *Journal of Accounting education, 49*, 100638. doi:https://doi.org/10.1016/j.jaccedu.2019.100638

Taskin, B. &. (2022). Impact of digital literacy and problematic smartphone use on life satisfaction: Comparing pre-and post-covid-19 pandemic. *European Journal of Investigation in Health, Psychology and Education, 12*(9), 1311-1322.

Tifferet, S. (2019). Tifferet, S. (2019). Gender differences in privacy tendencies on social network sites: A meta-analysis. *Computers in Human Behavior, 93*, 1-12. doi:https://doi.org/10.1016/j.chb.2018.11.046

Torous, J. W. (2019). Creating a digital health smartphone app and digital phenotyping platform for mental health and diverse healthcare needs: an interdisciplinary and collaborative approach. *Journal of Technology in Behavioral Science, 4*, 73-85.

Treffinger, D. J.-D. (2023). *Creative problem solving: An introduction* (4 ed.). New York: Routledge.

UNESCO. (2018). *A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2.* UNESCO Institute for Statistics.

Urien, B. E.-G. (2019). WhatsApp usefulness as a communication tool in an educational context. *Education and Information Technologies, 24*, 2585-2602.

Van Hooijdonk, M. M. (2023). Creative problem solving in primary school students. *Learning and Instruction, 88*, 101823. doi:https://doi.org/10.1016/j.learninstruc.2023.101823

Van Laar, E. V. (2020). Measuring the levels of 21st-century digital skills among professionals working within the creative industries: A performance-based approach. *Poetics, 81*, 101434. doi:https://doi.org/10.1016/j.poetic.2020.101434

Voňková, H. Č. (2019). The Application of Anchoring Vignettes in the Analysis of Self-assessment of ICT Skills: A Pilot Study Among Czech Secondary School Students. *Empowering Students for Life in the Digital Age: IFIP TC 3 Open Conference on Computers in Education, OCCE 2018* (pp. 243-252). Linz, Austria: Springer International Publishing.

Yuen, S. &. (2023). Instagram and social capital: youth activism in a networked movement. *Social Movement Studies, 22*(5-6), 706-727. doi:https://doi.org/10.1080/14742837.2021.2011189