The Effectiveness of Digital Module Based-POE (Predict-Observe-Explain) with Computer-Assisted Feedback to Improve Student Understanding of Physics Concept

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Abstract*—The objective of this study is to develop a digital module-based Predict-Observe-Explain (POE) in a valid, practical, and efficient form to enhances students' conceptual understanding of physics. The Plomp model, including three stages—preliminary research, development or prototype phase, and assessment phase—was employed in the experimental research. A questionnaire and interview sheet were used to discover school problems in preliminary research. A digital module-based POE with computer-assisted feedback was designed in the next phase. Around five experts gave their evaluation of the prototype. The practicality test was conducted by one-to-one evaluation (three students) and small group (nine students). The validity and practicality sheets were used in both stages. The assessment phase was conducted as quasi-experiment with pre-post tests design that involving two experiments classes with a total sample of 60 students. The test was used to collect data in this stage. All the data were analyzed using the percentage technique, Aikens' V formula, N-Gain, and Wilcoxon test. Preliminary research showed that many problems occur in physics learning; students find it difficult to understand physics, there is a limited digital module used in learning, the teacher dominates physics learning, and giving feedback to the students is not optimal. Digital module-based POE with computer-assisted feedback appears as a solution. Based on validity evaluation by experts, it showed that the prototype was valid (V = 0.94). Practicality evaluation by one-to-one and small groups obtained that the product was very practical. Then, the effectiveness test results based on the N-gain showed the improvement of students' conceptual understanding in the moderate category (0.58 and 0.30 for experiment class and control class, respectively). Based on the Wilcoxon test, Sig. (2-tailed) < 0.05, which indicates a significant effect. In summary, digital module-based POE with computer-assisted feedback effectively improves students' conceptual understanding of physics.

***Keywords*—digital module, physics learning, conceptual understanding, Predict-Observe-Explain (POE), computer-assisted feedback**

I. Introduction

Physics is a subject that needs reasoning and logic skills to succeed. In studying physics, student have to be focused on understanding scientific ideas to construct a cohesive and completely integrated conceptual framework [1, 2]. Ideal physics learning is done through experimental activities that make students master physics concepts and make learning student-centered [3].

In fact, during the two years of the COVID-19 outbreak in Indonesia, physics learning was carried out online. Consequently, students find it difficult to understand some of the topics delivered [4]. Because teachers are not providing enough supervision and giving students insufficient feedback, the implementation of online learning is not working as it should [5]. So, during the two years of the COVID-19 outbreak, the implementation of online physics learning has caused students' understanding of physics material to decline [6].

Understanding concepts is one of the abilities that students must have to learn physics successfully. Understanding concepts will enable students to understand the process, memorize formulas, and produce knowledge from the discoveries made [2]. Efforts can be made to increase students' understanding of concepts by applying appropriate learning models and teaching materials in physics learning [7].

Based on questionnaires distributed to several high schools in the city of Padang with 667 students as respondents, physics learning problems were found due to the implementation of online learning during COVID-19. As many as 79% of physics learning is still teacher-centered, 74% of students still use printed teaching materials, only 49% of learning allows students to carry out observation activities, only 53% of students receive feedback from the teacher during learning, and only a few digital teaching materials available in physics learning [8]. The large percentage of problems in physics learning causes students to have a poor understanding of concepts in several physics' topics, such as kinematics [9]. Learning still dominated by teachers is also a problem with physics learning because it does not allow students to discover concepts [6, 10]. To support optimizing students' understanding of concepts, digital teaching materials based on student-oriented learning models are necessary, in this case, focusing on digital modules.

The usage of digital modules in learning physics has grown significantly. The use of digital modules has been proven to

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provide practicality for students in independent learning [10, 11]. Digital modules can be accompanied by video, audio, simulations, and other interactive media that can encourage the ability to understand concepts. Various media that can be collected into one digital module provide new experiences for students to improve motivation and understand concepts more deeply [12, 13]. Using digital modules in learning increases students' understanding of concepts [10, 13–15]. Furthermore, the Predict-Observe-Explain (POE) model served as a basis for the development of digital modules that have been shown to enhance students' understanding of concepts [16–19].

The POE model was developed to assess students' ability to make predictions about natural phenomena and their causes [20]. By using POE model, students may engage in direct interaction while exploring an idea. This model makes use of many tasks, including guessing or predicting (Predict), observing activities connected to the hypothesis (Observe), and evaluating the hypothesis' relevance considering the observations (Explain). Students are involved their initial knowledge in predicting, making observations, and explain the results of their findings [20, 21]. Students will be more confident in the concept if the predicted results match the observation results. If the student's guess is incorrect, the student can seek an explanation for the inaccurate prediction. Students will experience a change in concept from an incorrect concept to a correct one. With the use of this POE model, teachers may improve their students' comprehension of topics and address the issue of misconceptions in physics learning [22, 23].

Technological developments can not only make printed modules into digital modules. In terms of providing feedback to students, it can also be done through digital modules, particularly on evaluation results [24]. Digital modules, with the help of computer-assisted feedback, can be a solution for students and teachers in the learning process [22, 23]. Computer-assisted feedback is an additional program that can provide feedback on evaluation questions contained in digital modules. Notifications in the form of correct answers in completing assignments/questions can help students assess the depth of their understand of various ideas based on the material that the teacher has taught [3, 25, 26]. Meanwhile, for teachers, it can be used as an additional tool for assessing how well their students understand the concepts, they are teaching. Therefore, feedback can be used to evaluate learning for students in learning and for teachers in delivering material during the learning process [27, 28].

The digital module in this research was created using PowerPoint integrated with the i-Spring suite software. This software can be used to create teaching materials [29]. Several menu options exist for creating teaching materials, quizzes, books, dictionaries, and even simulations. This digital module can be operated via smartphone and computer, making it easier for students to use it anytime, anywhere [30, 31]. Therefore, this research aims to see the effectiveness of using POE-based digital modules accompanied by computer-assisted feedback in increasing students' conceptual understanding of kinematics. This research aims to develop valid, practical, and effective digital modules to improve students' understanding of concepts.

II. Literature Review

A. Digital Module

In the learning process, teaching materials are essential to the continuous learning of students [31]. Teaching materials are a collection of tools or learning tools that include learning materials, approaches, and assessments to achieve learning objectives. The focus of this study is teaching materials in the form of modules. Modules are one of the learning tools students can use in the learning process. Through modules, students can carry out learning independently based on the elements contained in the module [32, 33]. A module is a comprehensive stand-alone teaching material made up of a set of learning activities designed to assist students in achieving objectives [32].

Currently, modules are presented in printed form, electronic form, or digital modules. Digital modules are books in soft file form that students can open and read anywhere and anytime [33]. Students can enhance their ability or understanding by using digital modules as self-directed learning resources [34]. The utilization of digital learning modules has the potential to enhance student motivation [35], support teaching and learning interactions [30], optimize student and teacher learning activities, and allow students to become the center of teaching and learning activities [36].

B. POE Model

The POE model was introduced by White and Gunstone in 1995 in their book "Probing Understanding" [37]. The POE model is a model that has implications for student learning outcomes based on a constructivist view. In learning, the implementation of the According to the POE model, students will predict demonstration results, carry out experiments, discuss predictions generated by demonstration results, and provide an explanation of the expected results based on their observations. Students can develop their scientific abilities through these three activities to increase their understanding of their study concepts.

The POE model has been proven to improve various student abilities in the classroom. Students can interact actively in discovering concepts based on initial predictions they make and prove them directly through experimental activities so that the knowledge gained will be more meaningful and long-lasting [20, 29]. Applying the POE model in the classroom has also been proven to improve student's critical thinking skills and motivation in learning [35]. In its implementation, the POE model requires more thorough preparation. Apart from that, how can teachers organize learning activities optimally suited to the available time.

C. Computer-Assisted Feedback

Computer-assisted feedback is a tool that can be used to provide feedback. In this case, the feedback given can be in the form of explanations regarding answers to questions related to conceptual understanding. So that students' understanding increases [38]. Feedback is an activity carried out by teachers to help each student respond to the work of students who experience difficulties in learning [28]. The feedback can be in the form of direct suggestions, criticism, motivational guidance, or appreciation such as appreciation for the learning outcomes of the students. Corrective feedback can deepen students' understanding [3]. Evaluating students' work, for example, when the teacher gives an assignment, the teacher carefully inspects and underlines the answers that are still wrong and provides short notes as information for correcting answers [26].

Providing feedback is intended to reinforce students, where in the questions given, there is feedback on each question's answer, both for correct answers and for wrong answers. Giving feedback helps students identify their areas of strength and weakness in solving physics problems and helps them understand topics deeper [28, 29].

III. Methods

A. Research Type

Design research is a type of study used to develop interventions in the form of learning strategies, materials, products and systems that solve complex educational problems [39]. The Plomp model was utilized for development, and it consisted of three stages: 1) preliminary research, which consists of conducting needs analysis and reviewing literature; (2) development or prototyping phase, which consists of prototype design, formative evaluation, and prototype revision; (3) assessment phase, which consists of being tested and evaluated in practice [2]. More concisely, the research stages are presented in Fig. 1.

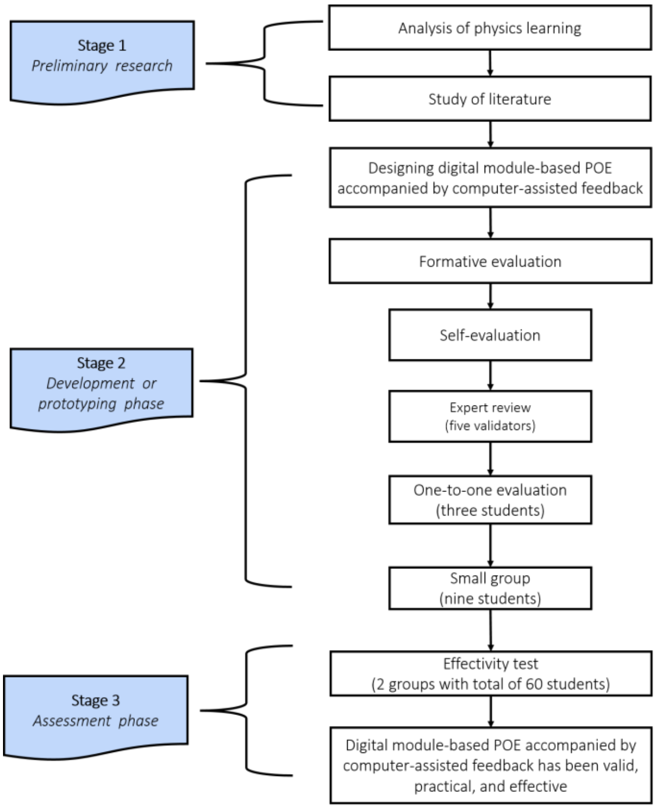

Fig. 1. Research procedure.

Based on Fig. 1, Plomp's development model has three stages. Need analysis is carried out in the first stage by distributing questionnaires to students (667 students) and interviews with teachers (9 teachers). Questionnaire indicators and interview sheets include student characteristics, the use of teaching materials in physics learning, the application of learning models in the classroom, and the need for teaching materials for physics learning.

In the development or prototyping phase, the activities carried out are designing product template designs, evaluating product manufacture (self-evaluation and validity testing), producing product prototypes that have been revised according to expert opinions, and conducting small-scale field tests (one-to-one evaluation and small group) to obtain product practicality. Self-evaluation sheets, validation sheets, and practicality sheets (one-to-one evaluation and small group) are the research instruments utilized at this stage. The validation indicators are material substance, visual communication display, learning design, software utilization, and POE-based teaching material assessment (Appendix Table A1). A total of 3 students with three groups of student ability categories were involved in the one-to-one evaluation. Furthermore, in the small group test, nine students at SMAN 1 Padang were involved. After taking part in the small group test, students were asked to fill out a practicality sheet with indicators of ease of use, attractiveness, benefit, and effectiveness and efficiency (Appendix Table A2).

Next is the assessment phase, which is an activity to test the effectiveness of the products produced. The effectiveness test was conducted through a quasi-experiment with a pre and post-test design. The population in this study was 180 students consisting of six classes of XI science senior high school in Padang city, West Sumatra. The prerequisite tests (normality test and the homogeneity test) had been done to determine two sample classes based on their midterm score in physics. Cluster random sampling was used to determine sample classes. A total of 60 students were involved in this study. The research design can be seen in Table 1.

Table 1. Pre-test and post-test design

	Pre-test	Treatment	Post-test
Control class	O_1	-	O_2
Experiment class	O_1	X	O_2

O_1 : Pre-test
O_2 : Pos-ttest
X : Learning process using digital module-based POE with computer-assisted feedback

Based on Table 1, an experimental class was given the treatment by using digital module-based POE, while control class was given printed teaching material which usually used in the school. Both classes were given a pre-test and post-test on the ability to understand concepts of kinematics. The instrument indicators refer to the physics lesson syllabus for class XI high school.

B. Technique of Data Analysis

Preliminary research data was obtained using percentage techniques—calculating prototype validity using Eq. (1).

$$V = \frac{\sum(ri - lo)}{[n(c-1)]} \quad (1)$$

V: Aiken's index; ri: score given by the validator; lo: lowest rating score; c: highest rating score; n: number of raters.

In this case, five validators assessed the prototype being developed. From the Aiken V index calculation, the prototype is said to be valid if $V \geq 0.87$ and $V < 0.87$ is invalid [40]. Meanwhile, practicality data for the one-to-one evaluation and small group stages were analyzed using Eq. (2). Interpretation of the practicality results (P) follows the following rules: 0–20 (not practical), 21–40 (less practical), 41–60 (quite practical,) 61–80 (practical), and 81–100 (very practical).

$$P = \frac{X}{Y} \times 100\% \quad (2)$$

P: practicality score; X: total score.

$$Y: maximum\ score < g >= \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{S_{m\ ideal} - \langle S_{pre} \rangle} \quad (3)$$

g: gain score; S_{post}: posttest score; S_{pre}: pretest score; $S_{m\ ideal}$: maximum score.

Assessment phase data in the form of pre-test and post-test differences were analyzed using Average N-Gain (Eq. (3)). Interpretation of g results follow the following rules: $g < 0.3$ (low), $0.3 \leq g \leq 0.7$ (moderate), and $g > 0.7$ (high) [24]. Hypothesis testing was carried out using the non-parametric statistical test Wilcoxon Test [41]. The null hypothesis in this study is that there is no significant difference between the use of digital module-based POE and computer-assisted feedback on increasing students' conceptual understanding. If Sig. (2-tailed) < 0.05, the null hypothesis is rejected and Ha is accepted. The null hypothesis of the effectiveness test in this study was "there is no significant difference of the use of digital module to the improvement of conceptual understanding of student. Meanwhile, the alternative hypothesis in this study was "there is significance difference of the use of digital module to the improvement of conceptual understanding of student".

IV. Result

A. Preliminary Research

Student and teacher needs were analyzed as a preliminary study for this research. Researchers have published the preliminary research results in the journal [8]. In general, the results of preliminary research are presented in Table 2.

Table 2. Results of preliminary research

Indicators	Responses
Student characteristics	67% of students have difficulty understanding physics
The use of teaching materials in physics learning	Teachers dominate 79% of physics learning
The implementation of learning models in the classroom	74% of physics learning still uses printed teaching materials
The need for teaching materials for learning physics	80% of students need digital modules accompanied by feedback

Several issues in learning physics were discovered during preliminary study. First, students need help studying physics, especially kinematics. Second, learning is still dominated by teachers. Third, there is a need for more availability of digital teaching materials. From the problems found, it is known that students need digital teaching materials that can provide independent learning through scientific activities and are accompanied by feedback on evaluations.

The researcher also asked some questions to the teachers to obtain a description of the physics learning that had been carried out so far and what problems had occurred. The results of interviews showed that most teachers still use printed teaching materials based on something other than certain learning models. In physics learning, teachers have never used digital modules. In addition, learning still uses direct explanations and rarely provides opportunities for students to conduct group discussions and observations. Apart from that, students still consider physics difficult, one of which is kinematics. There are still many students who need clarification. Lack of learning time causes teachers not to provide optimal feedback on students' abilities.

B. Development and Prototyping Phase

Based on the problems obtained in the preliminary study, a POE-based digital module accompanied by computer-assisted feedback was designed. The digital module was designed using PowerPoint and i-Spring Suite software. The published results of digital modules can be made in HTML and .exe extensions to be used offline or online.

Digital modules are designed according to module components such as covers, learning activities, student activity sheets, evaluations, bibliography, and developer biographies. The learning activities contain video, audio, text, simulations, and POE-based student activity sheets. There are three learning activities for kinematics. At the end of the learning activity, there is an evaluation equipped with conceptual questions and feedback. A more complete design of POE-based digital modules accompanied by computer-assisted feedback has been published in a journal by researchers [42].

Following the design of the digital module, self-assessment and expert validation are conducted. There are five indicators: 1) Material substance, 2) Visual communication display, 3) Learning design, 4) Software utilization, and 5) Teaching material-based POE. The results of product validation by experts are presented in Table 3.

Table 3. Results of the validity test

	Indicators					Average
	1	2	3	4	5	
Aiken's V index	0.92	0.95	0.95	0.95	0.94	0.94
Category	Valid	Valid	Valid	Valid	Valid	Valid

The product developed is valid for all assessment indicators based on expert validation assessments. All validator comments and recommendations are utilized to enhance and revise modules.

The revised product was then tested for practicality in a one-to-one evaluation by three students in the high, moderate, and low ability categories, with one student in each category. The results of the one-to-one evaluation by each category of students are presented in Fig. 2.

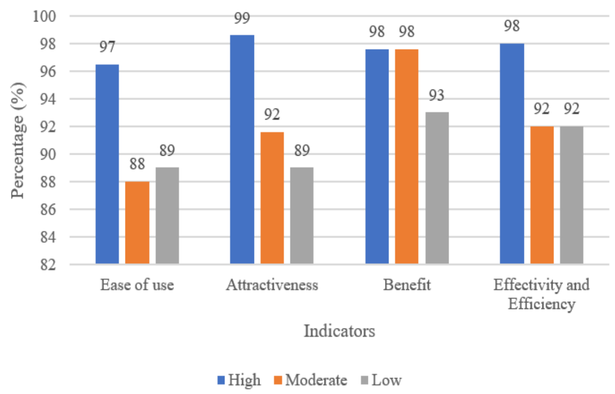

Fig. 2. Result of one-to-one evaluation.

It can be seen from the one-to-one evaluation that all assessment indicators are in the very practical category by the three groups of students. Suggestions and comments from students (users) written in the questionnaire have been revised.

Next, a small group evaluation was conducted to try out one learning activity related to straight-motion quantities in the digital module. The POE model is implemented in learning activities. Students try to predict the cases given at the beginning of learning and make observations to prove the predictions made. Finally, students explain the solution to the case and evaluate the predictions made. Documentation of small-group practicality test is shown in Fig. 3, and the results of small-group practicality test is presented in Table 4.

Fig. 3. Screenshot of prediction and observation activity.

Table 4. Results of small group evaluation

Indicators	Score	Category
Ease of use	83.87	Very Practical
Attractiveness	84.19	Very Practical
Benefit	83.87	Very Practical
Effectivity and Efficiency	83.22	Very Practical
Average	83.78	Very Practical

The small group practicality test revealed that digital modules are very practical in physics learning. It means that the digital module developed has practicality in ease of use, attractiveness, benefit, and effectivity and efficiency. Therefore, digital modules can be tested for their effectiveness at the assessment stage.

C. Assessment Phase

The assessment phase is carried out to determine how effective of the developed digital modules. A total of three kinematics learning activities were carried out using POE-based digital modules accompanied by computer-assisted feedback in experiment class. Each learning activity carries out a formative assessment of students' conceptual understanding abilities. The results of assessing students' conceptual understanding before treatment up to the third meeting showed an increase in both classes, as shown in Table 5.

After meeting 3, a post-test was given to students to assess if there was a difference in their concept understanding abilities before and after using the digital module. Table 6 shows the outcomes of pre-test and post-test data analysis for the two classes.

Table 5. Results of students' conceptual understanding

Class	Meeting			
	Pre	1	2	3
Experiment class	45.1	53.2	58.9	64.5
Control class	42.33	45.20	51.0	56.55

Table 6. Results of the pre-test and post-test of both classes

	Pre-test		Post-test	
	Experiment Class	Control Class	Experiment Class	Control Class
Total participant	30	30	30	30
Average score	45.1	42.33	77.1	70.67
Maximum score	80	69.38	86.7	73.88
Minimum score	20	29	60	46.34
Deviation standard	15.75	8.02	6.37	5.34

Based on Table 6, students' ability to understand physics concepts on particle kinematics is still low for the two classes, namely 45.1 and 42.33 for experiment class and control class, respectively. Next, a post-test is carried out to see students' abilities after learning using digital modules. Student post-test results increased for both classes; the average post-test score for experiment class was 77.1, and for control class was 70.67. This average value shows an increase in the pre-test score obtained by each student in the experiment class. It means there are differences in students' ability to understand concepts before and after using digital modules in physics learning in experiment class.

The average N-Gain analysis was carried out to determine how much the student's understanding of concepts had improved after utilizing the digital module in the experiment class. Table 7 shows the average N-Gain analysis results.

Table 7. Results of average N-Gain

	Experiment Class	Control Class
Pre-test–Post-test	0.58	0.30
Category	Moderate	Low

The average value of students' conceptual understanding through the average N-Gain showed that g value was 0.58 (experiment class) and 0.30 (control class), which is in the moderate and low category, respectively.

It is necessary to test the prerequisites based on the students' pre-test and post-test scores. The prerequisite tests in question are the normality test and the homogeneity test. The results of the normality and homogeneity tests are shown in Table 8.

Table 8. Results of normality and homogeneity tests

Test		Experiment Class		Control Class	
		Pre-test	Post-test	Pre-test	Post-test
Normality test	Kolmogorov-Smirnov (Sig.)	0.200	0.000	0.200	0.006
	Shapiro-Wilk (Sig.)	0.409	0.003	0.875	0.002
	Conclusion	Normal	Not normal	Normal	Not normal
Homogeneity test	Levene Statistic (Sig.)	0.000		0.535	
	Conclusion	Not homogenous		Homogenous	

Based on Table 8, the prerequisite test is not met. Because each class's pre-test and post-test scores are not normally distributed, and the data is not homogeneous (experiment class) or homogeneous (control class). So, the next test carried out is non-parametric, namely the Wilcoxon Test. Wilcoxon test to compare students' scores before and after using digital module-based POE accompanied by computer-assisted feedback.

Wilcoxon test result shows Z index is −4.772 and significance (2-tailed) is 0.000. The Sig. (2-tailed) < 0.05, so the null hypothesis is rejected. There is a significant different in students' understanding of concept between experiment class dan control class. Therefore, using POE-based digital modules accompanied by computer-assisted feedback effectively increases students' understanding of concepts.

V. Discussion

Problems in the field often occur in various schools in Padang, West Sumatra. The lack of effective learning during the COVID-19 pandemic has caused students' understanding of concepts to decrease [6]. Students find difficult in physics [7]. Students are forced to understand the material independently without being given feedback because of the limited online learning platforms that teachers can understand [43]. Another main problem in schools is the use of rarely applied models of learning. So, learning is still dominated by teachers in the form of direct explanations [44]. In addition, there is a need for online learning facilities, including digital teaching materials [8, 20]. POE-based digital module design accompanied by computer-assisted feedback is a solution to problems in the field.

The digital module in this study was validated by five experts on five assessment indicators: material substance, visual communication display, learning design, software utilization, and teaching material-based POE, which had reached valid criteria [45]. In the material substance aspect, the digital module is valid because the kinematics components are correct by the curriculum so that they can achieve learning objectives. Digital modules have an attractive visual appearance, so they are one of the criteria for increasing user interest [34]. Furthermore, the learning design aspects in digital modules can be adapted to the curriculum and students' abilities. In addition, various types of software can provide feedback to users, especially on evaluations inside digital modules [29]. The POE model, which is integrated into digital modules, can allow students to carry out scientific activities independently [18].

The digital module in this study has a very high level of practicality from all aspects of assessment, namely material, learning design, implementation, display, and effectiveness and efficiency in one-to-one and small-group evaluations. Practicality assessment is used to see the practicality of the product for use by users and its usefulness in learning [24]. In the material aspect, the digital module presents material that is easy to understand and clear for users. Clarity of material and an attractive display based on the presented phenomena can foster students' interest in learning. Moreover, digital modules can be used anytime and anywhere and can optimize costs and time [31, 32], which are important aspects of the practicality of a module.

Valid and practical products are tested for their effectiveness in physics learning. The use of POE-based digital modules accompanied by computer-assisted feedback in learning provides new experiences for students in learning. Predict-Observe-Explain (POE) activities have an important role in increasing students' understanding of concepts [46–49].

The first prediction activity in the digital module is to display phenomena and questions that require students to hypothesize. Displaying phenomena and problems as an opening for learning will further arise students' curiosity. Students' skills in predicting answers to the questions presented will train students to think critically and be able to make hypotheses by using their prior knowledge [21].

Second, observing activities are experimental activities carried out based on phenomena and hypotheses that have been created. This experimental process aims to build students' activeness and critical thinking skills in finding information from what they obtain, so that the understanding gained from experimental activities will be more long-lasting and meaningful [48]. In addition, using interactive simulations like the PhET simulation during observation has improved students' conceptual understanding of physics [2, 15, 50, 51].

Third, the explained activity in the digital module is presented as analytical questions from the results of observations in previous activities. Analytical questions in open-ended problem have been shown to improve students conceptual understanding and critical thinking abilities [51]. Students' answers to questions will show their ability to understand their acquired concepts.

At the end of the learning activities in the digital module, there is an evaluation. The evaluation questions are intended to see students' understanding of concepts after learning. The questions are arranged in different representation formats so that students can optimize their knowledge in answering the problems [52]. For each question, students will be given feedback on their answers. Feedback has been proven to play a role in providing reinforcement and, simultaneously, identifying the answers' weaknesses [3, 29, 40].

Each stage of POE activities in the digital module strongly increases students' understanding of concepts [17, 18, 32]. Moreover, the practicality of digital modules can enable students to learn independently easily and effectively. Providing direct feedback in digital modules also makes students more confident in knowing their ability to understand concepts.

VI. Conclusion

Based on the result of analysis, the developed digital module was valid with 0.94 of Aiken's coefficient and practical with 83.78% by students. Valid and practical digital modules are available to solve physics learning problems. Digital modules have proven to be effective in learning physics. POE-based digital modules accompanied by computer-assisted feedback is effective in increasing students' understanding of concepts. The POE model can be recommended to be applied in physics learning so that students can gain knowledge through scientific activities that will provide meaningful learning.

Appendix

Table A1. Indicator of validity

Components	Sub components	Indicators
Material substance	Correctness	The material presented contains correct concepts so that misconceptions are avoided
		The material presented is based on the principles and laws in physics
		The Physics equations presented are

		correct
		The Physics symbols presented are correct
		The material presented is factual so that it can increase students' understanding
	Material coverage	Material substance in accordance with a scientific principle
		The material in accordance with indicators and learning objectives
		The material covers all learning indicators
		The material presented can broaden and deepen students' knowledge
		The presentation of material is arranged systematically
	Up to Date	The material presented is in accordance with scientific developments
		Digital modules can be used anywhere
		Digital modules can be used at any time
		Digital module can be accessed via a PC or smartphone
		Digital modules use UpToDate software
	Legibility	The sentences used do not cause misunderstandings
		The sentences used are easy to understand
		The sentences used are effective
		The writing of physics formulas is correct
		The use of punctuation marks that comply with standard Indonesian grammar rules
Visual communication display	Navigation	The navigation works well
		The navigation is easy to understand
		The navigation is consistent
	Menu	The menu is clear and systematic
		The menu represents the title of the material
	Typography	Using appropriate font size
		Writing legible letters
		The color combination is attractive
		The appearance of the layout elements is consistent
	Media	Some images support learning
		Some videos support learning
		The image captions presented clarify the presentation of the material
		The images and videos are arranged attractively
	Layouts	The display design is proportional
		The display design is attractive
Learning design	Title	The titles presented the material
		The cover is in accordance with the material
	Core and basic competencies	Core competencies are in accordance with content standards
		The basic competencies are in accordance with core competencies
	Indicators and learning objectives	The indicators presented the basic competencies
		The learning objectives are in accordance with the indicators
	Material	Learning materials are by in accordance with indicators and learning objectives
		The material presented is equipped with example questions
	Problem example	Example questions given are by the learning objectives
		Example questions are accompanied by a discussion of the questions
	Evaluation	The evaluation questions presented are in accordance with the indicators
		The discussion presented in the evaluation questions is correct
	Developer	There is the identity of the developer
Utilization of software	Interactivity	Digital modules provide interactivity
		Digital module increases users' motivation
	Supporting software	Digital module can be directly accessed via a PC/smartphone
		The Digital module operates well
	Originality	The digital module is an original work
Teaching material-based POE	Stages	The worksheets help students to predict, observe and explain during the learning process
		The worksheets contain questions for prediction, observation, and explanation activities
		The prediction activity is carried out by presenting pictures/videos about kinematics material
		The observations activity is carried out by *online* practicum activities using PhET software or real practicum activities related to kinematics
		The explanation activity contains questions that explain the concept

Table A2. Indicators of practicality

Indicators	Statements
Ease of use	I can use digital module easily
	I understand the users' instruction of digital module
	I understand the material presented in the digital module
	I can use navigation and button of digital module easily
	I can implement "predict" activity in the digital module easily
	I can implement "observe" activity in the digital module easily
	I can implement "explain" activity in the digital module easily
Attractiveness	I am interested in the cover of digital module
	I am interested in the color combination of digital module
	I feel that illustrations (Pictures, video, and simulation) presented in the digital module is attractive
	I am interested in POE activities presented in the digital module
Benefit	I feel that digital module makes me easier to understand the physics concepts
	I can use digital module to learn independently
	I can use digital module as an additional learning resource
	I can use feedback presented in the digital module to strengthen my understanding
Effectiveness and efficiency	I can optimize the use of learning time by using digital module
	I can save cost by using digital module

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed significantly to the completion of the work. HH and WSD validated the research instrument; PDS analyzed the data and wrote the paper; DS developed the design of the digital module; NIA conducted preliminary research; EBA conducted effectiveness test; RA validated the test instrument; FA and FRR validated the product. All authors had agreed the final version of the paper.

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