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Design and Validity of E-Modules Based on Cognitive Conflict in Measurement Materials for Grade X SMA/MA

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ABSTRACT

Physics education in school often faces challenges due to students' limited conceptual understanding and persistent misconceptions, particularly in measurement topics. This study aims to develop and evaluate an e-module based on cognitive conflict to address these issues. The research was a development study based on the Plomp model, which includes preliminary research, prototyping, and an assessment phase. The resulting e-module presents a structured learning sequence that activates students' preconceptions, introduces cognitive conflict, facilitates the discovery of key concepts, and promotes reflection. Designed using Canva Pro and Heyzine Flipbook, that e-module was validated by experts, achieving a high score of 0.95, indicating its suitability in terms of content, visual design, learning structure, and software functionality. The findings suggest that a cognitive conflict-based e-module is an effective tool for enhancing conceptual understanding and reducing misconceptions in the measurement, offering practical value for physics learning in schools.

Keywords: E-modules, Cognitive Conflict Learning Model, Measurement, Misconception

I. INTRODUCTION

The rapid advancement of information and communication technology (ICT) has significantly influenced educational practices, transforming how learning is designed and delivered [1,2]. Among various ICT-based innovations, the electronic module (e-module) has emerged as an effective medium that combines interactivity, visualization, and independent learning features [3,4]. Its integration is particularly relevant in physics education, a subject often perceived as difficult due to its abstract and mathematical nature [1,5]. Through visual representations and simulations, e-modules enable students to understand complex phenomena such as motion, waves, and measurements that are otherwise challenging to explain using conventional teaching resources [6,7].

However, the potential of e-modules can only be fully realized when combined with suitable learning models. One effective approach for fostering conceptual understanding is the cognitive conflict learning model, which intentionally exposes learners to contradictions between their existing conceptions and scientific explanations [3,8]. This confrontation encourages students to reflect on their prior knowledge, restructure inaccurate ideas, and develop a scientifically accurate understanding [9,10]. Research has shown that learning based on cognitive conflict promotes critical thinking, conceptual change, and motivation to learn [11,12].

Conceptual understanding forms the foundation of meaningful physics learning because it allows students to connect theoretical principles with practical experiences in everyday life [1,5]. Nevertheless, diagnostic assessments conducted at SMAN 15 Padang revealed that students' comprehension of measurement concepts remains low. Only 10% of students demonstrated correct understanding, while 45% showed misconceptions, and the remaining 45% lacked understanding. Common errors included the belief that mass and weight share identical units and dimensions, as well as the misconception that width and height are separate base quantities [6]. Interviews with physics teachers further indicated that digital e-modules have not yet been used, and the cognitive conflict model is rarely applied in classroom practice. Misconception identification is still performed informally through oral questioning [7].

Although several studies have examined the use of digital modules in physics education, limited research has focused on developing validated e-modules that integrate the cognitive conflict approach for measurement topics. Consequently, misconceptions regarding measurement concepts persist among students [3,10,12]. Addressing this issue requires teaching materials that not only incorporate interactive digital media but also actively engage learners in resolving conflicts between their initial ideas and scientific understanding [8,11].

Therefore, this study aims to design and validate an e-module based on the cognitive conflict learning model for the topic of measurement. The research seeks to describe the characteristics and validity of the developed e-module, ensuring its practical application in classroom learning to enhance students' conceptual understanding and reduce misconceptions.

II. METHOD

This study adopts a development research approach, also known as design research, which emphasizes the creation and validation of educational products. The research was conducted following the Plomp model, consisting of three main phases: (1) preliminary research, (2) development or prototyping, and (3) assessment [13]. In this study, the development process was limited to the second phase, focusing on expert review and product refinement of a cognitive conflict-based e-module on the topic of measurement in high school physics.

Preliminary Research Phase

The preliminary phase involved analyzing both student and teacher needs as well as reviewing relevant literature. Students' conceptual understanding of measurement was identified through diagnostic tests comprising three-tier questions that assessed answers, reasoning, and confidence levels. Teacher needs were explored through structured interview instruments addressing the use of teaching materials, learning models, methods for identifying misconceptions, and experimental activities related to measurement. A literature review was then conducted to examine prior studies on the effectiveness of teaching materials and learning models in supporting conceptual understanding.

Development (Prototyping) Phase

At this stage, the e-module prototype was designed and refined through an iterative formative evaluation process. The procedure began with self-evaluation by researchers to check technical accuracy, learning alignment, and visual presentation. The next step was validation, which involved three assessors with backgrounds in physics education, learning design, and media development. Each assessor evaluated the e-module based on four aspects: substance of the material, visual communication display, learning design, and software utilization. The evaluation used a Likert-type rating scale.

Instrument Validation and Data Analysis

Data analysis techniques are employed in the preliminary stage to categorize students' understanding into three categories: objective answer results, reasons for answers, and student confidence levels as indicated on test sheets. The categories consist of concept understanding, misconceptions, and a lack of understanding of the concept. Data from teacher interviews were analyzed using descriptive methods, while self-assessment responses were evaluated on a Likert scale. The self-assessment sheets were analyzed using percentage techniques:

$$Nilai = \frac{skor\ yang\ diperoleh}{skor\ maksimum} \times 100\%$$

The validity of the instrument was determined using Aiken's V index (V), which is calculated as follows (Source: Ref[14])

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

Table 1 presents the categories determined using Aiken's V index

Table 1. Validity Categories Using Aiken's V Index

Intervals	Category
V<0,92	Invalid
V>0,92	Valid

The product underwent expert validation to assess its accuracy and appropriateness. During this process, experts provided feedback and recommendations, which were subsequently incorporated to refine and enhance the developed products.

III. RESULTS AND DISCUSSION

Results

1. Preliminary Research Stage

   In the preliminary research stage, a concept comprehension analysis test was conducted on students, and interview instruments consisting of several questions were given to teachers at SMAN 15 Padang. The analysis of students' concept comprehension was conducted in class X Phase E.3, which consisted of 32 students. The average results obtained by students were 10% for the concept understanding category, 45% for the concept non-understanding category, and 45% for the misconception category. A considerable number of students continue to struggle with understanding the concepts and demonstrate misconceptions regarding measurement topics. Furthermore, the results of the needs analysis, obtained from interviews with several questions, showed that the current learning model and teaching materials used were ineffective in improving students' conceptual understanding and addressing their misconceptions about measurement materials. Innovations in the form of experimental activities and instruments for identifying conceptual understanding are needed to support more meaningful learning.

2. Development Stage Results

2.1. Cognitive Conflict-Based E-module Design

This phase involves developing e-modules to improve students' conceptual understanding and correct misconceptions in measurement topics. The e-module follows the structure outlined in the 2017 Practical Guidelines for Learning E-Module Development by the Ministry of Education and Culture. It is based on the cognitive conflict learning model, which includes four stages: (1) activation of preconceptions and misconceptions, (2) presentation of cognitive conflicts, (3) discovery of concepts and equations, and (4) reflection. Examples of these stages as applied in the e-module are presented below.

Fig. 1. Preconception Activation and Misconception Stage Design

During the phase of activating students' preconceptions and misconceptions, students interact with carefully designed statements designed to evaluate their understanding of the fundamental concepts of the topic. Students can select one of the options: correct (C), incorrect (I), or do not know (D). Their choices subsequently indicate whether they understand the concept (DUC), do not understand it (UC), or hold misconceptions (M). This stage aims to identify students' prior knowledge before they start learning, so that teachers can determine the appropriate learning strategies.

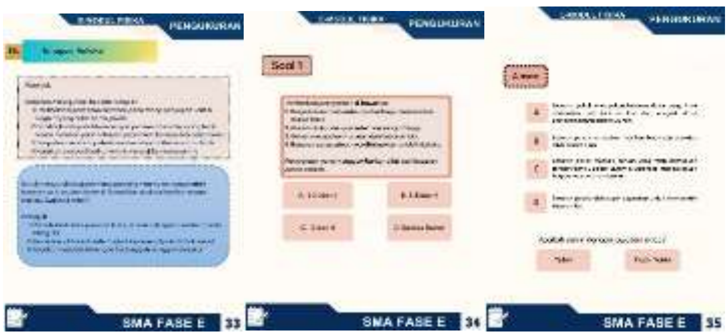
Fig. 2. Design of the Cognitive Conflict Presentation Stage

During the cognitive conflict presentation phase, students encounter phenomena related to the learning material that may trigger cognitive conflict. Students are asked to predict the outcome of the phenomenon by providing tentative answers to several questions presented and filling them in through a Google form created by the researcher. This phase seeks to stimulate students' conceptual thinking, serving as the initial step in guiding them to formulate new concepts based on scientific principles.

Fig. 3. Concept Discovery and Equation Design Stage

During the phase of discovering concepts and equations, several questions are presented to help students construct their knowledge. Students explore fundamental concepts and equations by engaging in experiments and collaborative discussions. Students can also submit their answers to a Google Form created by the researcher. This stage aims to form a deep conceptual understanding that will remain in the students' memory for a long time.

Fig. 4. Reflection Stage Design



During the reflection phase, students are asked to review the answers they have previously given after completing the process of discovering concepts and equations. Next, they are given evaluation questions on the measurement material in a three-tier format. This stage is designed to help teachers assess students' achievement and progress in understanding the material they have studied.

2.2. Self-Evaluation

After the researchers designed the e-module, they then conducted a self-evaluation stage. Self-evaluation is the stage of verifying the completeness of materials, correcting any errors, and adding or removing parts as needed, in accordance with the provisions. The results of the self-evaluation test conducted by the researchers themselves indicate that the e-module prototype design is complete, both in terms of the e-module's structure and the stages of the cognitive conflict-based learning model (PbKK). The aspects assessed in accordance with the e-module indicators are based on the e-module aspects, e-module components, e-module design, and PbKK model syntax. In the graph, each indicator aspect is displayed on the X-axis, while the values corresponding to each indicator are placed on the Y-axis in the XY coordinates. **Figure 5** presents the outcomes of the indicator mapping of the self-evaluation.

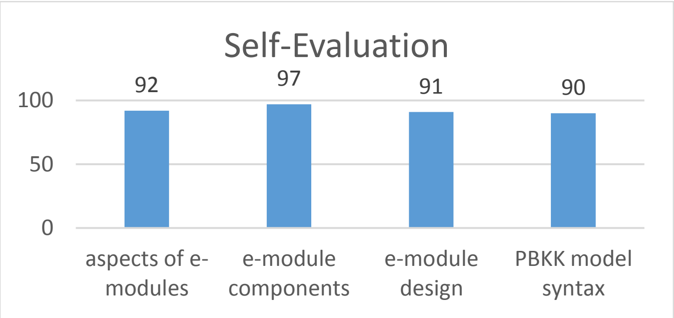


Fig. 5. Self-Evaluation Results

As illustrated in Figure 5, average scores across self-evaluation indicators in the cognitive conflict-based e-module, using measurement material, varied between 90 and 97. The average score obtained from the self-evaluation was 93, which is classified as very good for all indicators. The results of the assessment of the four aspects indicate that the cognitive conflict-based e-module on measurement developed by the researcher falls into the excellent category.

2.3. Validation test (*Expert Review*)

Validation was conducted by three assessors representing the domains of physics education, instructional design, and educational media. Each assessed four key components: material substance, visual communication, learning design, and software utilization. The results are summarized in Table 2.

Table 2. Summary of Validation Results for the Cognitive Conflict-Based E-Module

Component	Score Range	Mean Validity	Category
Material Of the Substance	0.94-0.97	0.95	Valid
Visual Communication Display	0.92-1.00	0.95	Valid
Learning Design	0.92-1.00	0.97	Valid
Software Utilization	0.92-1.00	0.94	Valid
Overall Mean	**-**	**0.95**	**Valid**

As presented in **Table 2**, all components obtained Aiken's V coefficients above 0.92, indicating that the developed e-module is valid across all evaluation aspects. The learning design achieved the highest mean score (0.97), followed by material substance and visual communication (0.95), and software utilization (0.94). Overall, the mean validity score of 0.95 demonstrates strong consistency among assessors, confirming that the e-module meets the criteria for a highly valid learning resource suitable for classroom use.

Discussion

The results of the preliminary analysis indicate that students still experience substantial misconceptions related to measurement concepts, consistent with previous findings that show physics learners often rely on intuitive but incorrect prior conceptions that hinder their conceptual understanding [6]. These misconceptions persist because traditional instruction does not generate sufficient cognitive conflict to encourage students to question their initial ideas. In line with the cognitive conflict framework, meaningful conceptual change occurs when students confront inconsistencies between their existing beliefs and scientifically accepted explanations, creating cognitive disequilibrium that must be resolved through restructuring of their mental models [3], [10], [11].

The development of the cognitive conflict-based e-module was designed to operationalize these theoretical principles through structured phases, including activation of preconceptions, conflict presentation, guided conceptual discovery, and reflection. These stages are aligned with the conceptual change model, which posits that learners must first become dissatisfied with their prior conceptions before adopting more coherent and plausible alternatives [12]. The inclusion of conflict-inducing scenarios, simulations, and reflective prompts aligns with findings from earlier research, which indicate that digital environments designed to generate cognitive conflict can improve students' reasoning and support the correction of misconceptions in physics learning [7], [15], [16].

The validation results, summarized in Table 2, show that all evaluated components achieved high validity scores, with an overall Aiken's V value of 0.95. This strong agreement among assessors demonstrates that the e-module is well-constructed in terms of content organization, pedagogical coherence, visual communication, and software integration. The high score in the learning design component reflects the effective sequencing of cognitive conflict stages, which is essential for supporting conceptual change. These findings align with earlier studies on cognitive conflict-based digital learning materials that also reported high levels of validity in content, design structure, and visualization [15], [16], [17].

Despite these promising results, this study has limitations. The research focused solely on the development and validation phases; therefore, the practicality and effectiveness of the e-module in real classroom settings have not yet been examined. Previous studies emphasize that practicality testing is crucial to ensure that students can use the material effectively and that it supports measurable improvements in conceptual understanding [18]. Future research should therefore include classroom trials to evaluate usability, learning outcomes, and the extent to which the e-module can reduce misconceptions during actual instruction.

IV. CONCLUSION

This study involved the development of an interactive cognitive conflict-based e-module for Grade X measurement material. The product was constructed in accordance with the 2017 practical guidelines for e-module development and includes essential structural components such as a cover, introduction, glossary, concept map, learning objectives, learning activities, material reinforcement, and a summary. The instructional design applies the cognitive conflict learning model, which includes four stages: activation of preconceptions, presentation of conflict, guided concept discovery, and reflection. Developed using Canva Pro and Heyzine Flipbook, the e-module obtained an overall Aiken's V score of 0.95, indicating strong validity across material content, visual presentation, learning design, and software implementation.

Although the product demonstrates high validity, further research is recommended to evaluate its practicality and effectiveness in classroom settings. Future studies should investigate how the e-module supports students' conceptual understanding and its potential to remediate misconceptions in measurement topics.

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