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VALIDITY AND PRACTICALITY OF A COGNITIVE CONFLICT-BASED ELECTRONIC ASSESSMENT ON WORK AND ENERGY TO EVALUATE HIGH SCHOOL STUDENTS' CRITICAL THINKING SKILLS

Amalia Salsabila[1], Fatni Mufit[1*], Yenni Darvina[1], Emiliannur[1]

[1] *Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*
Corresponding author. Email: fatni_mufit@fmipa.unp.ac.id

ABSTRACT

The integration of information and communication technology (ICT) in education has encouraged the use of electronic assessments to support the evaluation of higher-order thinking skills, particularly critical thinking in physics learning. However, existing assessments are still limited in effectively measuring these skills. This study aims to develop a cognitive conflict-based electronic assessment on work and energy and to determine its content validity and practicality in evaluating high school students' critical thinking skills. This study employed a Research and Development (R&D) method using Plomp's model, which consists of preliminary research, development or prototyping, and assessment stages. The subjects were physics teachers and students of State Senior High School 10 Padang with varying levels of critical thinking skills. The instruments included a validation sheet and a practicality questionnaire. Content validity was analyzed using Aiken's V index, while practicality was analyzed using percentage techniques. The results showed that the developed assessment has a high level of content validity, with an average Aiken's V value of 0.85, categorized as "highly valid," and is highly practical, with scores above 96% across all evaluation stages. Therefore, the assessment is suitable for evaluating students' critical thinking skills in physics learning and can be used as an effective tool to support the improvement of learning evaluation quality.

Keywords: *Electronic Assessment, Cognitive Conflict, Critical Thinking, Work and Energy*

I. INTRODUCTION

The rapid advancement of information and communication technology (ICT) in today's world necessitates that people adapt in order to stay ahead of the curve and face global issues. ICT's function in the educational process is to support teachers in their instruction and students in their learning [1]. *E-learning, e-libraries, e-education, e-mail, e-laboratories, and e-assessment* are just a few of the technology-based activities that have emerged in the field of education as a result of technological breakthroughs [2]. The Fourth Industrial Revolution, which is ushering in an era of openness and globalization, is what defines the twenty-first century [3]. The 4C is *communication, collaboration, critical thinking, problem solving,* and *creativity and innovation* are the subjects of 21st-century education [4]. Electronic assessment has emerged as one of the major breakthroughs in the learning evaluation process due to technological advancements [5]. Electronic assessment is a method of evaluation where information and communication technology is used at every level [6]. In addition to increasing the effectiveness and efficiency of the evaluation process, the use of electronic assessments offers chances for the development of more interactive and context-specific assessment tools [7]. One platform that can be used for conducting electronic assessments is quizizz, a free web-based application that can be used to create interactive and engaging learning experiences [8].

One of the most important skills that students need to have in physics classes is critical thinking. Higher-order thinking, another name for critical thinking, is crucial for addressing problems [9]. Students must acquire this ability in order to evaluate their own reasoning and make wise choices [10]. Analyzing, evaluating, and

synthesizing information as well as making judgments based on logic and evidence are all components of critical thinking [11]. In order to gain a deeper knowledge, critical thinking is an intentional, deliberate, and reflective cognitive activity that involves information analysis and argument evaluation [12]. urthermore, interpreting, analyzing, evaluating, and drawing conclusions in evidence-based decision-making are all components of critical thinking [13]. Students' critical thinking abilities are greatly enhanced by physics education through conceptual comprehension and scientific problem-solving [14]. Allowing pupils to take charge of their education can also tangentially encourage the growth of their critical thinking abilities [15]. Overall, previous studies emphasize that critical thinking is a crucial skill in physics learning; however, students' abilities in this area remain low and require more effective assessment strategies.

Nonetheless, a number of research show that pupils critical thinking abilities are still comparatively low. Some kids often just have procedural problem-solving skills, they are unable to evaluate the solutions logically or connect them to real-world situations [16]. With a proportion of 53.84%, high school pupils' critical thinking abilities in physics classes are in the low range [17]. None of the students achieve the high level, while the majority fall into the low to extremely low groups. In particular, with reference to the subjects of labor and energy [18]. Students' ability to critically assess business and energy-related texts is extremely low, with an average score of 37.1%. All aspects of critical evaluation, including interpretation, analysis, inference, explanation, evaluation, and self-regulation, demonstrate low proficiency [19]. The tests utilized in the classroom have a direct correlation with students' inadequate critical thinking abilities [20]. Higher-order thinking abilities like analysis (C4) and evaluation (C5) are not yet adequately measured by current examinations, which are still dominated by questions at lower to intermediate cognitive levels like comprehension (C2) and application (C3). Additionally, the tests utilized at SMA Negeri 10 Padang do not yet satisfy the criteria for critical thinking abilities, according to [12]. This suggests that pupils' critical thinking abilities have not yet been adequately assessed by the test.

The majority of the questions were still at the low to intermediate cognitive levels, according to an examination of 20 questions on the subjects of work and energy utilized in schools. There were just two questions at the analysis level (C4), four at the understanding level (C2), four at the application level (C3), and none at the evaluation level (C5). At SMA Negeri 10 Padang, the use of technology in evaluation has not yet reached its full potential. Despite being used on a number of digital platforms, electronic tests have not been created expressly to assess pupils' critical thinking abilities [21]. Furthermore, the concept of cognitive conflict has not yet been included into the assessment process of the electronic tests utilized in schools [22].

The concept of cognitive conflict is one strategy that can be employed to enhance pupils' critical thinking abilities. When students' past knowledge and newly learned material diverge, cognitive conflict arises, forcing them to examine and assess ideas [23]. It has been demonstrated that using the cognitive conflict phenomenon greatly enhances students' critical thinking abilities when learning physics [24]. Furthermore, cognitive conflict motivates students to assess their comprehension and make rational deductions [25]. There are still many obstacles in the way of developing assessment tools for measuring critical thinking abilities in physics education, especially when it comes to creating test items that can fully evaluate higher-order thinking abilities [26].

However, previous studies have primarily focused on the development of electronic assessments or the implementation of cognitive conflict separately, so the integration of both in a single assessment tool is still limited. In addition, existing electronic assessments have not been specifically designed to measure students' critical thinking skills through cognitive conflict-based items, particularly in work and energy materials. Therefore, this study offers a novel contribution by integrating cognitive conflict into an electronic assessment to specifically evaluate students critical thinking skills. In light of these problems, an electronic test based on cognitive conflict that can thoroughly measure students' critical thinking abilities is required. This study aims to examine the validity and practicality of a cognitive conflict-based electronic assessment on work and energy for evaluating high school students' critical thinking skills.

II. METHOD

The goal of this research and development (R&D) project is to create an electronic assessment instrument that will test students' critical thinking abilities based on the phenomenon of cognitive conflict in the context of work and energy [27]. The R&D approach was selected since this study produces and assesses a product's quality in the form of an assessment tool in addition to examining the phenomena. The Plomp model, which has three phases *preliminary research, development or prototyping, and assessment phase* is the development model that is employed [28]. The Plomp model was chosen because it is appropriate for the methodical creation of educational goods through the phases of needs analysis, design, evaluation, and ongoing refinement. SMA Negeri 10 Padang

physics instructors and students with poor, moderate, and high critical thinking abilities made up the research subjects. Purposive sampling was utilized to pick subjects, taking into consideration the representativeness of students' skill levels so that the generated product may be broadly applied across a wide variety of student characteristics. The themes chosen were intended to give a thorough grasp of the product's usefulness in teaching physics.

In order to discover assessment concerns at the school, a requirements analysis was carried out during the preliminary research phase through interviews with physics teachers and an examination of the questions used in instruction. The goal of the development or prototype phase is to create an electronic assessment instrument based on cognitive conflict in line with critical thinking skill indicators. This stage involves creating test items, designing the assessment format, establishing scoring rules, and incorporating the phenomena of cognitive conflict into the test items. To guarantee the product's quality in terms of validity and practicality, a staged formative evaluation was then carried out, which included *self-evaluation, expert review, one-on-one evaluation, and small-group* evaluation [12]. The research instruments used included expert validation forms, interview forms during the *preliminary research phase*, and usability questionnaires during the *one-on-one and small-group phases* [29]. A Likert scale with a score range of 1 to 5 was used to collect quantitative data for the study, which shows how much the respondents agreed with the assertions.

Table.1 Likert Scale

Likert Scale	Response Categories
1	Strogly Disagree
2	Disagree
3	Undecided
4	Agree
5	Strongly Agree

Source: [30]

Aiken's V validity index can then be used to examine the validity test findings. The formula for *Aiken's V* is as follows:

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

$$s = r - I_0 \quad (1)$$

The following categories are then used to interpret the *Aiken's V* score.

Table 2. Decisions Based on Aiken's V Index

Interval	Kategori
≤ 0.4	Invalid
$0.4 < V \leq 0.8$	Valid
$0.8 > V$	Highly valid

Source: [31]

The results of student and teacher questionnaires from the one-on-one and small-group phases were used to do a percentage-based practicality analysis. In order to determine the practicality categories, the analysis process involved calculating the ratio of the obtained scores to the maximum possible values, which were subsequently translated into percentages.

$$Score = \frac{Score\ obtained}{maxmimum\ score} \times 100\% \quad (2)$$

The following table displays the criteria used to interpret the results.

Table 3. Categories of Practicality Level

No	Persentage(%)	Criteria
1.	0% - 20%	Not practical
2.	21% - 40%	Less practical
3.	41% - 60%	Fairly practical
4.	61% - 80%	Practical
5.	81% - 100%	Very practical

Source: [32]

Three students with varying skill levels (low, medium, and high) and two physics teachers participated in the *one-on-one* usability test. Nine students who also represented these three ability levels took the *small-group test.* This grouping was created to evaluate the product's appeal, usability, and comprehensibility for a range of student skill levels.

III. RESULTS AND DISCUSSION

RESULT

Based on the cognitive conflict phenomena, the results of this study include the validity and practicality of an electronic assessment developed to evaluate students' critical thinking skills in work and energy materials. The validity of the instrument was analyzed using *Aiken's V index* by expert validators.

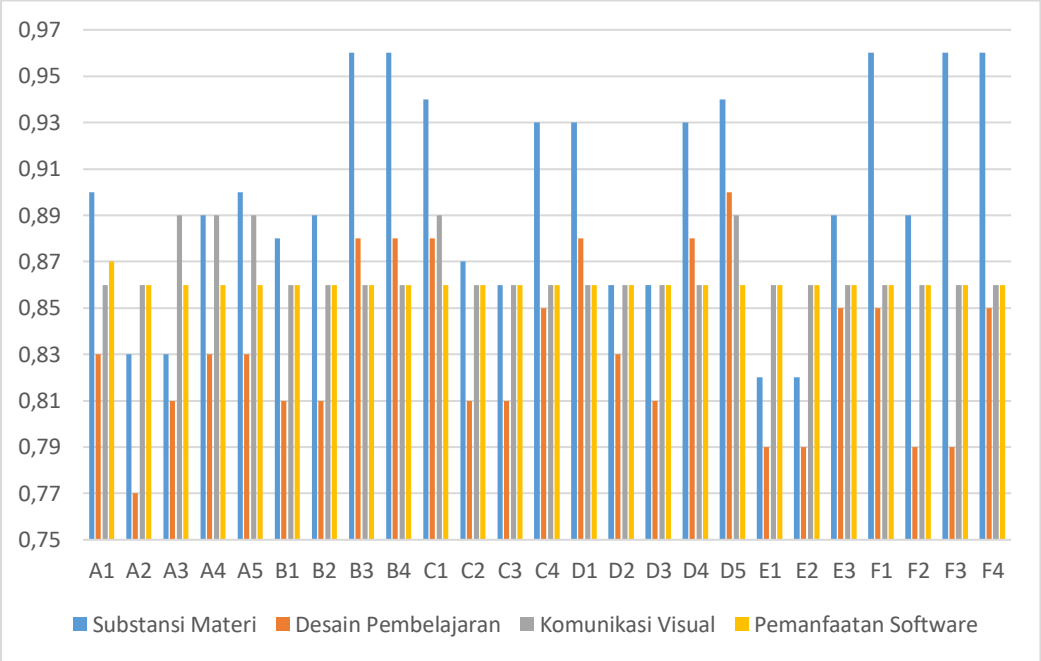

Figure 1. Diagnostic Assessment Validation Results

Figure 1 presents the validation results of the diagnostic assessment, showing the Aiken's V value for each test item. The results indicate that all items fall within the valid to highly valid categories, with an average value of 0.85, which is classified as "highly valid." The *Aiken's V* values range from 0.78 to 0.92, indicating that all 20 items are acceptable and do not require elimination. However, several items were revised based on validators' suggestions to improve clarity and alignment with critical thinking indicators [12].

The high validity of the content aspect indicates that the test items are conceptually accurate and consistent with work and energy principles. In contrast, the instructional design aspect shows relatively more variation, suggesting that the presentation of cognitive conflict in some items still requires improvement to better stimulate students' critical thinking processes. Meanwhile, the aspects of software utilization and visual communication show consistent results, indicating that the assessment is clear, systematic, and easy for students to understand. This finding suggests that although the technical quality of the electronic assessment is already strong, further refinement is needed in designing cognitive conflict situations that effectively challenge students' reasoning.

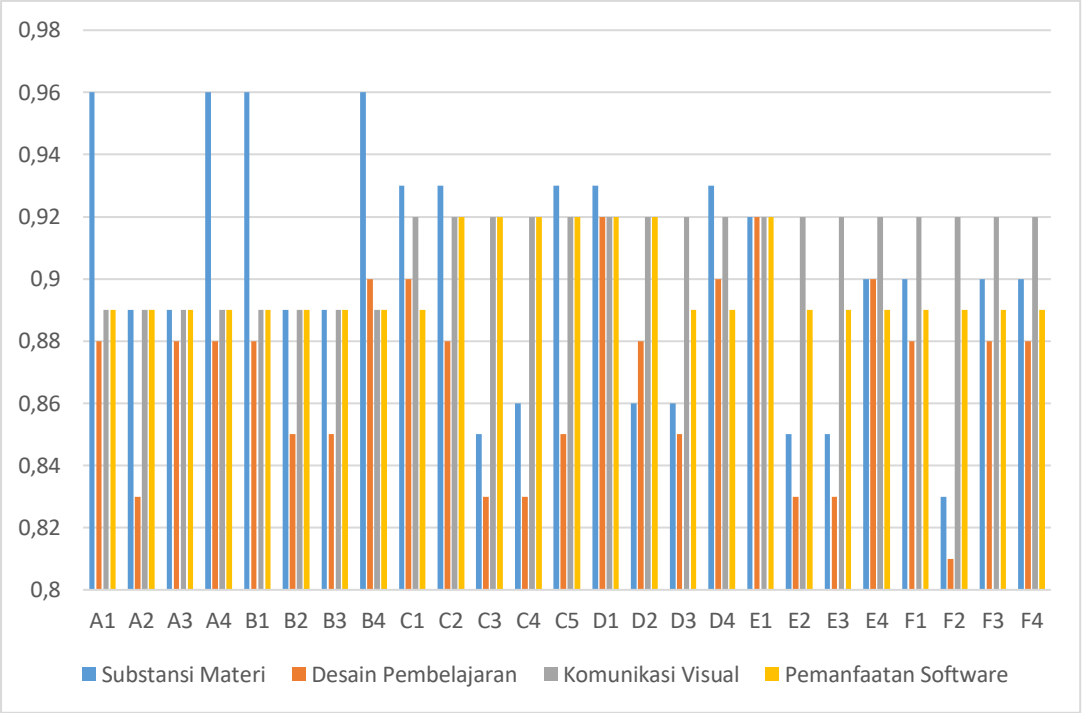

Figure 2. Summative Assessment Validation Results

Figure 2 presents the validation results of the summative assessment. Compared to the diagnostic assessment, the summative assessment shows a more consistent pattern with generally higher scores. This indicates that revisions made after the initial validation successfully improved the quality of the instrument. The smaller variation among items also reflects a higher level of agreement among validators.

The high validity results indicate that the developed assessment instrument meets the criteria of content validity, allowing it to accurately measure students' critical thinking skills [26]. This also confirms that the integration of cognitive conflict into the assessment contributes positively to the quality of test items, particularly in promoting higher-order thinking. Overall, the validity analysis demonstrates that the developed instrument is not only valid but also shows improved quality after revision, with strong internal consistency across items.The practicality of the developed electronic assessment was evaluated through teacher and student responses in the one-to-one and small group stages. The results of the teacher practicality test are presented in Table 4.

Table 4. Results of the Teacher Practicality Test

Aspect	Score (%)	Category
Ease of Use	98,33	Very Practical
Appeal	91,67	Very Practical
Efficiency	96,67	Very Practical
Benefits	100	Very Practical
Total	**96,11**	**Very Practical**

Table 4 shows that the overall practicality score from teachers is 96.11%, which falls into the "very practical" category. The highest score is found in the benefit aspect (100%), indicating that teachers perceive the assessment as highly useful in supporting the learning process. This suggests that the electronic assessment is effective in facilitating evaluation activities and can enhance efficiency in classroom assessment.

Table 5. *One-to-One* Practicality Results

Aspect	Score (%)	Category
Ease of Use	96.67	Very Practical
Appeal	96.67	Very Practical
Efficiency	95	Very Practical
Benefits	98.33	Very Practical
Total	**96.67**	**Very Practical**

The results of the one-to-one practicality test are presented in Table 5. The overall score is 96.67%, categorized as "very practical." These results indicate that students find the assessment easy to use, attractive, and efficient. This implies that the interface and structure of the assessment support students' engagement and understanding during its use.

Table 6. *Small Group* Practicality Result

Aspect	Score (%)	Category
Ease of Use	95.24	Very Practical
Appeal	97.33	Very Practical
Efficiency	97.78	Very Practical
Benefits	97.78	Very Practical
Total	**97.03**	**Very Practical**

The results of the small group practicality test are presented in Table 6, with an overall score of 97.03%, which also falls into the "very practical" category. The consistently high scores across all aspects indicate that the assessment is suitable for use by students with different levels of critical thinking ability. This suggests that the developed product is not only practical but also adaptable to diverse student characteristics. Overall, the practicality results from teachers and students consistently indicate that the developed electronic assessment is highly practical in terms of usability, attractiveness, efficiency, and benefits. This consistency strengthens the reliability of the practicality findings and shows that the product can be effectively implemented in physics learning.

DISCUSSION

The findings of this study indicate that the cognitive conflict-based electronic assessment demonstrates a very high level of validity. This high validity reflects that each test item has been systematically developed in alignment with critical thinking indicators. The use of *Aiken's V* index ensures that the instrument accurately represents the construct being measured [31]. A high validity score implies that the instrument is able to measure students' critical thinking skills appropriately, as each item corresponds to the defined indicators [33]. Furthermore, the test items were constructed based on the five stages of critical thinking, namely basic clarification, bases for decision, inference, advanced clarification, and strategies and tactics [12]. This alignment strengthens the content validity of the instrument and supports the development of higher-order thinking skills.

The integration of cognitive conflict into the assessment design also contributes significantly to the validity of the instrument. Cognitive conflict encourages students to reconsider their initial understanding and engage in deeper reasoning processes when encountering contradictions between prior knowledge and new information [23]. This process leads to conceptual reconstruction and enhances critical thinking, as supported by previous studies [34].

The improvement observed in the summative assessment compared to the diagnostic assessment indicates that the revision process played an important role in enhancing the quality of the instrument. However, the relatively lower performance in the instructional design aspect suggests that designing effective cognitive conflict situations remains a challenge. This is because cognitive conflict requires a balance between problem complexity and clarity of context to optimally stimulate students' analytical thinking. If the conflict is not well designed, it may fail to trigger deep reasoning.

In terms of practicality, the findings show that the developed electronic assessment is highly practical. This can be explained by the advantages of electronic assessments, which offer flexibility, efficiency, and ease of use in the evaluation process [5]. The high practicality scores from both teachers and students indicate that the assessment is user-friendly, visually appealing, and efficient in supporting classroom activities. This

is consistent with previous findings that electronic assessments improve the effectiveness of evaluation processes compared to conventional methods [7].

The use of digital platforms such as quizizz further strengthens the practicality of the assessment. quizizz provides interactive features, automatic scoring, and flexible access, which support both teachers and students in the assessment process [35]. In addition, quizizz allows integration of multimedia elements and real-time feedback, making the assessment more engaging and meaningful for students [36]. The interactive nature of this platform also increases student participation and motivation during assessment activities [37]. This indicates that technology integration not only improves efficiency but also enhances students' engagement in learning.

Additionally, the incorporation of cognitive conflict into computerized assessments fosters the growth of critical thinking abilities. Students are urged to use logical reasoning to analyze, assess, and develop conclusions when confronted with contradicting circumstances. This method complements the features of learning physics and enhances higher-order thinking abilities [25]. In addition, the use of interactive electronic assessments further supports student engagement and promotes deeper understanding through active learning processes [38].

IV. CONCLUSION

This study aimed to develop a cognitive conflict-based electronic assessment on work and energy and to determine its content validity and practicality in evaluating students' critical thinking skills. The results show that the developed assessment has a high level of content validity, with an average Aiken's V value of 0.85, categorized as "highly valid." In addition, the practicality results indicate that the assessment is highly practical, with scores exceeding 96% across teacher and student evaluations. These findings indicate that the developed electronic assessment is suitable for use in physics learning, particularly in assessing students' critical thinking skills. The integration of cognitive conflict into the assessment provides an alternative approach to support the development of higher-order thinking skills. Therefore, this assessment can be used as an effective tool to improve the quality of learning evaluation in physics.

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