Development Test of Advanced Clarification Critical Thinking (TACCT) in Work and Energy Material for Student in Higher Education

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***Abstract* – This study aims to develop a valid and reliable instrument test of advanced clarification critical tinking (TACCT) in work and energy materials. This test is used to measure the ability to judge facts using the right concept, ability to handle misunderstanding, ability to identify unstated assumptions, predictive thinking skills, ability to resolve label usage errors, ability to think metacognitively, and ability to solve problems in sequence. This instrument test was made using the design and development research method. Pre-analysis, development test, and assessment to test the validity of the product. The TACCT instrument was tested twice, namely the expert test to determine the validity of the content and constructs and the usage test to find out the test items were valid and reliable. Determination of content and construct validity was obtained from the average results of three experts using a validation sheet. While the determination of valid and reliable items by testing items for 42 students was analyzed using SPSS version 18. Based on the results of the content validity expert test, a score of 3.78 was obtained with a valid category, as well as construct validity with a score of 3.61 with a valid category. The results of the empirical test of 14 items only 10 questions are included in the valid category and the questions are in the reliable category with an index score of 0.96. So TACCT is feasible to be used for research.**

***Keywords* – Measurement, Critical Thinking, Work and Energy, Higer Education**

I. INTRODUCTION

The undergraduate program is oriented towards preparing students to become intellectuals and/or scientists who have a culture and have the competitiveness to be ready to work professionally, as well as create jobs (Ministry of Education and Culture of the Republic of Indonesia , 2012). Achieving these goals requires adequate capabilities. The acquisition of abilities is obtained through a learning process that emphasizes the internalization of knowledge, attitudes, and skills (Presidential Regulation of the Republic of Indonesia, 2012). Another opinion is that higher education learning orientation needs to prepare graduates to become professionals (Sulisworo et al., 2020).

Achieving professionalism in work requires critical thinking skills (Winch & Gingell, 2008). Because the ability to think critically will optimize one's intellectual capacity so that they get the best decisions (Davies, 2015; Ennis, 2016). Thus critical thinking is a skill that students need to have as a provision in the world of work (Bassham & Wallace, 2013; Facione, P. & Gitten, 2016).

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Many critical thinkers have put forward the concept of critical thinking. Critical thinking is a person's ability to think reflectively to make decisions that can be trusted and can be done (Ennis, 2016). Agree with this thought, critical thinking is the skill of making decisions or solving problems with the principle of open thinking, namely accepting other opinions with accountable arguments. (Halpern, 2014). Decision-making needs to prioritize rationality (McPeck, 2017). Critical thinking skills require mental processes such as observing, categorizing, selecting (Siegel, 1998), with several cognitive activities such as including interpretation, analysis, evaluation, conclusion, explanation, and self-regulation (Facione, P. A., 2015). Thus, Ennis' opinion is relevant to the opinion of other critical thinkers.

Ennis has divided critical thinking skills into five components, including basic clarification, basic support, inference, advanced clarification, A facilitative ability (Ennis, 2015). One of the five components, critical thinking ability, advanced clarification, is relevant for higher education due to age and curriculum demands. Factors after students as adult students who put a lot of emphasis on evidence and rationality in thinking (Arend, 2012), (Moreno, 2010). In fact, in terms of the objectives of the KKNI curriculum for higher education, the target is that students must be able to make decisions based on sharing resources (Presidential Regulation of the Republic of Indonesia, 2012).

II. PROBLEM STATEMENT

The measurement of advanced clarification of critical thinking has not been fully considered by researchers in the field of education. The indicators that have been measured in various studies are only indicators of judge definitions, using appropriate criteria (Herawati et al., 2020; Irwanto et al., 2018; Maknun, 2020; Pursitasari et al., 2020; Rahmi et al., 2019; Zain & Jumadi, 2018). The second indicator is attributed and judged unstated assumptions (Herawati et al., 2020; Irwanto et al., 2018; Maknun, 2020; Pursitasari et al., 2020). On the other hand, Ennis has divided seven indicators of critical thinking ability for further clarification, including 1) judge definitions, using appropriate criteria 2) handle equivocation appropriately, 3) attribute and judge unstated assumptions, 4) think suppositional 5) deal with fallacy labels, 6) be aware of, and

check the quality of, their own thinking (metacognition), 7) proceed in an orderly and reasonable manner appropriate to the situation (Ennis, 2015). So, it is necessary to develop valid instruments to measure the test of advanced clarification critical thinking (TACCT).

This study aims to develop TACCT for students who take basic physics courses on work and energy materials to produce a valid and reliable test instrument. With this test instrument, it is hoped that students will get used to giving rational arguments in answering questions. In the field of education, this instrument can be a reference for researchers who want to measure the advanced clarification of critical thinking

III. LITERATURE REVIEW

Critical Thinking

There are various views on the definition of critical thinking skills. Judge *et al.*, (2009) Critical thinking is the examination of ideas or information from objects by paying attention to the values and attitudes of a person. The main point of critical thinking is argumentation based on relevant evidence.

The next opinion is that critical thinking is a challenge of ideas by evaluative considering different perspectives or being able to think wisely (Moon 2007). Critical thinking is a variety of skills and intellectual dispositions to identify, analyze arguments and truth claims to overcome biased prejudices (Wallace 2001). Likewise Dunn *et al*., (2009)) critical thinking is a process of evaluating reasoning, reflective processing, active cognitive strategies for making decisions.

Based on various opinions regarding critical thinking skills, there are similarities and differences in critical thinking concepts proposed by critical thinkers. The similarity of the concept of critical thinking is an activity that aims to make decisions by considering facts or information (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Facione, 2009). On the other hand, the difference of opinion lies in the scope of the field of science. The first opinion, critical thinking ability is special, that is, it can only be applied to one field of science (Halpern, 2003; McPeck, 2017; dan Johnson; Siegel, 2010). While the second opinion is that the ability to think critically is general, that is, this ability is general and can be applied in various fields of science (Ennis dalam Mason, 2009; Paul, Elder, 2014; Facione, 2009).

The second opinion is that the ability to think critically is generally chosen as the basis for research because it is more suitable for research purposes. Among the opinions of general critical thinking skills, critical thinking skills conceptualized by Ennis were chosen as the basis for training students. The implication of Ennis' opinion is that critical thinking skills can be developed through various courses. This research is specific to the physics subject matter of work and energy and the type of advanced clarification of critical thinking components.

Measurement of Critical Thinking

Measurement of critical thinking skills can be done using a test instrument. TACCT was developed from indicators that have been made by Ennis. So that the principle of developing TACCT on work and energy materials follows the standard for making tests that have been developed by Ennis.

Determination of indicators is the basis for developing critical thinking ability tests by limiting the scope of making questions. The scope of indicators measured in the Connecticut and California areas includes basic clarification, conclusion, clarity and problem solving (Ennis, 1985a). The development of an open-ended essay test Ennis also makes a list of abilities to be measured such as considering definitions based on criteria, seeing one's reasons and assumptions, dealing with misunderstandings by providing rational reasons, seeing other possibilities, responding to false claims appropriately (Ennis, 1985b).

Second, namely the form of critical thinking tests, there are four types of test forms in measuring critical thinking, namely multiple choice, and essay (Ennis, 1985a; 1985b;1993; Ennis *et al*., 1964). The test is in the form of multiple choice, namely by giving questions that contain information or a certain condition, then there is a statement that each student is asked to choose the correct answer (Ennis et al., 1964). The next type of test is an essay or open-ended test. The purpose of making essay tests is to facilitate students to assess an argument and formulate arguments to answer the questions that have been given (Ennis, 1993).

The form of the test in the form of an essay was chosen for the research plan. This is because the test in the form of an essay can facilitate critical thinking, the test taker can decide the answer after considering the various information or previous knowledge so that it also shows caution in determining the answer. (Ennis, 1985b). An open mind is highly correlated with assessing the credibility of sources and identifying assumptions (Ennis, 1993), as well as further clarification indicators as a basis for measurement, namely assessing statements based on assumptions and deduction processes (Ennis, 2016).

The selection of essay tests is in accordance with empirical facts that convey the benefits of the essay test form, namely providing more opportunities to express students' thinking strategies. Written test questions can stimulate important aspects of critical thinking, namely analyzing, rethinking, or generating new ideas (Franco, Costa, and Almeida, 2018; Franco *et al*., 2018; Tiruneh *et al*., 2017; Asmawati *et al*., 2018). Reinforced by the results of the literature study, the results show that the basic principles of making critical thinking test instruments include presenting phenomena, open tests, and testing rationality (Saputro, Tukiran, *et al.*, 2020).

IV. METHOD

This research is a type of design and development research that aims to create a TACCT instrument with the stages of development of instrument test, validation of

instrument test, and usage of instrument test. (Richey & Klein, 2014), (Suartama et al., 2019). Each stage is described in a sub-chapter in the method section of this paper.

Development Of Instrument Test

This stage obtains indicators of advanced clarification of critical thinking in making questions on the subject of work and energy. The seven indicators include 1) judge definitions, using appropriate criteria 2) handle equivocation appropriately, 3) attribute and judge unstated assumptions, 4) think suppositionally 5) deal with fallacy labels, 6) be aware of, and check the quality of, their own thinking (metacognition), 7) proceed in an orderly and reasonable manner appropriate to the situation (Ennis, 2015). Each indicator is made up of two questions to anticipate if there are invalid questions, so at this stage, fourteen questions are developed in the form of an essay or open-ended test. Open-ended tests adapt development examples The Ennis-Weir Critical Thinking Essay Test (EWCTET)

Validity of Instrument Test

This stage contains tests that have been developed, expert validation tests will be carried out. The expert validation test was carried out by three experts in the development of a test instrument that would assess the content and construct validity of TACCT (Akhdinirwanto et al., 2020), (Ratumanan & Laurens, 2006). Aspects of measuring content and construct validity are shown in Table 1.

TABLE 1: ASPECTS OF MEASURING CONTENT AND CONSTRUCT VALIDITY OF TACCT

Validity	Aspect	Indicator
Test Content Validity	Clarity of questions	1. Clarity of question instructions. 2. Clarity of essay question form. 3. Clarity of the meaning of the question in the question.
	Content accuracy	1. The accuracy of the item with the study material. 2. The accuracy of the questions with advanced clarification of critical thinking. 3. The accuracy of the answer keys on each item of the question.
Test Construct Validity	Unbiased the meaning of the question	1. Items have a complete idea. 2. The words used do not have multiple meanings.
	Language accuracy	1. Language is easy to understand. 2. Under the intellectual level of students. 3. The written language is following the PUEBI rules.

Three experts assess the making of TACCP through focus group discussion activities, the results of the assessment will be averaged to measure the level of content and construct validation with predetermined criteria (Ratumanan & Laurens, 2006).

TABLE 2: EVALUATION OF CONTENT AND CONSTRUCT VALIDITY MEASUREMENTS.

Interval Skor	Category	Conclusions
$3.6 \leq P \leq 4$	Very valid	Can be used without revision
$2.6 \leq P \leq 3.5$	Valid	Can be used with a little revision
$1.6 \leq P \leq 2.5$	Less valid	Can be used with a lot of revision
$1 \leq P \leq 1.5$	Not valid	It cannot be used and still requires consultation.

Usage of Instrument Test

The usage of the instrument test was carried out through the TACCT empirical trial to determine the level of validity and reliability of the questions. Questions were given to 42 students who had taken basic physics courses on work and energy. both are calculated through the SPSS version 18 application. Determination of each valid question using the person test (P.<0.01) and reliable will be calculated the value of Cronbach's Alpha has a percentage 0.75 (Mapeala & Siew, 2015).

V. FINDINGS

Based on the analysis of the sub-topics of business and energy, the indicators for advanced clarification of critical thinking are described in Table 3. So that each indicator is easy to develop into essay questions, each indicator is given an operational explanation.

TABLE 3: MATRIK ADVANCED CLARIFICATION OF CRITICAL THINKING IN WORK AND ENERGY MATERIAL

Number.	Sub-chapters Work and Energy	Indicator of Advanced Clarification of Critical Thinking	Items Total
1	Main Concept Work and Energy	Judge definitions, using appropriate criteria.	2
		Handle equivocation appropriately.	2
		Attribute and judge unstated assumptions.	2
2	The Relation of Eork and Energy dengan Energi	Think suppositionally.	2
		Deal with fallacy labels.	2
3	Mechanical Energy	Be aware of, and check the quality of, their own thinking (metacognition).	2
		Proceed in an orderly and reasonable manner appropriate to the situation.	2

The selection of the essay test form aims to give students the opportunity to express arguments in answering each question (Asmawati et al., 2018), (Franco et al., 2018), (Tiruneh et al., 2017). The main characteristic of this test

instrument is that each question has an explanation with the aim that students can be responsible for what has been chosen. The following is an illustration of the TACCT test format that has been developed.

Example of TACCT items

Indicator: Make the right decision based on the business concept.

Description of the problem
Look at the following picture.

Two blocks A and B are initially at rest on a horizontal smooth board as shown in the figure. The mass of block B is equal to 4 times the mass of block A. If both blocks are pushed with the same constant force they move with the same length of the path.

Question
Do you think the value of the work done by the pushing force on block A and block B until they reach the finish line will be the same or different? Explain your answer with appropriate arguments.

Validity of TACCT

The validity of TACCT was carried out by three experts. Expert trials were measured to determine the content and construct validity. The expert received the TACCT draft one week before the FGD. After the FGD was carried out, the expert assessed the instruments that had been developed as shown in table 4.

TABLE 4: THE RESULTS OF CONTENT VALIDATION

Aspect	Score average			Total Average	Criteria
	Expert-1	Expert-2	Expert-3		
Clarity of questions	3.67	4	4	3.88	Very valid
Content accuracy	3.67	3.67	3.67	3.67	Very valid
Average	3.67	3.83	3.83	3.77	Very valid

Based on Table 5, the details of the content validity on the aspect of clarity of questions have a total average of 3.88 which are included in the very valid category. Content accuracy has a total average of 3.67 included in the very valid category. The results of all aspects of content validity that have been assessed by experts with a total average of 3.77 are included in the very valid category. While the results of construct validation are shown in Table 5.

TABLE 5: THE RESULTS OF CONSTRUCT VALIDATION

Aspect	Score average			Total Average	Criteria
	Expert-1	Expert-2	Expert-3		
Unbiased the meaning of the question	3.67	4	4	3.83	Very valid
Language accuracy	3.88	4	4	3.63	Very valid
Average	3.75	3.93	3.93	3.73	Very valid

Based on Table 5, the details of construct validity on the aspect unbiased the meaning of the question total of 3.83, which are included in the very valid category. Language accuracy has total average of 3.63 which is included in the very valid category. The results of all aspects of construct validity that have been assessed by experts with a total average of 3.73 are included in the very valid category

Usage of TACCT

TACCT was carried out by user trials to determine the validity and reliability of each item. A total of fourteen questions were tested on 42 students and obtained the validity of the items as shown in Table 6.

TABLE 6: RESULTS OF ITEM VALIDITY

Indicator advanced of clarification	Item number	Significance	Conclusions
Judge definitions, using appropriate criteria.	1	0,01	Valid
	2	0,01	Valid
Handle equivocation appropriately.	3	0,17	Invalid
	4	0,02	valid
Attribute and judge unstated assumptions.	5	0,01	valid
	6	0,00	valid
Think suppositionally.	7	0,02	valid
	8	0,00	valid
Deal with fallacy labels.	9	0,42	Invalid
	10	0,01	valid
Be aware of, and check the quality of, their own thinking (metacognition).	11	0,43	Invalid
	12	0,00	valid
Proceed in an orderly and reasonable manner appropriate to the situation.	13	0,43	Invalid
	14	0,00	Valid

Based on the results of the calculation of the validity test obtained ten valid questions which include questions number 1, 2, 4, 5, 6, 7, 8, 10, 12, and 14. While the invalid questions are questions on numbers 3, 9, 11, and 13. In addition to measuring the value of the validity of each item, the level of the TACCT instrument has also been tested.

Reliability is used to determine the extent to which the measurement results remain consistent, meaning that the test questions from time to time produce the same or relatively the same value. Questions that have been said to be valid are then tested for reliability using the Pearson formula which is calculated with SPSS version 18, the reliability is obtained in table 6.

TABLE 7: THE RESULTS OF THE RELIABILITY TEST OF THE DEVELOPMENT OF THE TEST INSTRUMENT

Valid question items	Index	Conclusions
1, 2, 4, 5, 6, 7, 8, 10, 12 and 14	0,96	Reliable

Based on table 6 the reliability index is obtained 0.96 thus the question is included in the reliable category (Mapeala & Siew, 2015).

VI. DISCUSSION

This research is an effort to develop an appropriate and reliable critical thinking ability test instrument at the higher education level, especially in the physics course on the subject of work and energy with the term TACCT. 14 item questions were developed based on seven indicators for advanced clarification including 1) judge definitions, using appropriate criteria 2) handle equivocation appropriately, 3) attribute and judge unstated assumptions, 4) think suppositionally 5) deal with fallacy labels, 6) be aware of, and check the quality of, their own thinking (metacognition), 7) proceed in an orderly and reasonable manner appropriate to the situation (Ennis, 2015).

Through FGD with experts, 14 items of content validity results obtained an average score of 3.73 included in the valid category as well as construct validity with an average score of 3.63 in the valid category (Akhdinirwanto et al., 2020), (Ratumanan & Laurens, 2006). Qualitatively, the validator provides input so that the sentences used in the development of item questions are more effective by using good discussion rules.

The results of the empirical test of 14 questions that have been tested as many as 42 students obtained 10 valid questions and 4 invalid questions. Based on the results of the reliability test of 10 valid questions, it is obtained 0.96 which is included in the reliable category (Mapeala & Siew, 2015). Thus the 10 questions that have been declared valid and reliable can be used to measure the advanced clarification of critical thinking.

The question development design has been adapted to The Ennis-Weir Critical Thinking Essay Test (EWCTET) in compiling essay tests or open-ended (Ennis, 1985). However, for the scoring criteria, there is a difference between EWCTET and TACCT. Ennis scores from -1 to +5 while TACCT scores from 0 to 3. This is because the test developed by Ennis is a general statement. Meanwhile, TACCT is specifically for physics courses specifically for the subject of work and energy which has concept certainty in answering, namely the concept of work, the theorem of work, and energy and mechanical energy. (Jewett, 2010), (Saputro et al., 2020)

VII. CONCLUSION

The development of TACCT has been carried out twice, namely the validation by experts and the validation usage test. Based on the expert test, 14 questions that have content validity and construct validity are included in the valid category. While the empirical test contained 10 questions that were declared valid and had met the 7 specified indicators and the questions were included in the reliable category. So that the 10 questions are worthy of being used as instruments to measure critical thinking skills for further clarification.

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