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Critical Thinking Instrument Test (CTIT): Developing and Analyzing Sundanese Students' Critical Thinking Skills on Physics Concepts Using Rasch Analysis

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Abstract--- *The purpose of this study is to develop and analyze the Critical Thinking Instrument Test (CTIT) of the Sundanese scholar at Cibeureum Tasikmalaya City West Java. The research method has been applied by the ADDA model (analyze, design, develop, and applicate). Participants who elaborate in this research are 26 (11 male students', namely "Pameget" and 15 female students', namely "Istri", the average age of them are about 17 years of Sundanese-tribe). The CTIT contains 10 questions that have been already analyzed by Rasch analysis. Rasch analysis explains the Sundanese-scholars at the Cibeureum region only answer confidently on easy questions. The data analysis including person reliability, item reliability, the validity of CTIT. Based on the analysis, it can be concluded that CTIT was reliable and valid to be implemented to assess students' critical thinking on fluid static although some items need to be revised.*

Keywords--- *CTIT, Critical Thinking, Sundanese, Rasch Analysis*

I. Introduction

Critical thinking skill is essential in physics learning because in physics learning alike with examination actions on subjects reaching since detecting, formulating complications, accumulating data, processing and investigating data, and finishing. Though in fact, the application of learning courses is not as much of reassuring in the accomplishment of thinking skills (e.g. Mabruroh & Suhandi, 2017; Malik et al., 2018; Rahim et al., 2019; Inda, 2020). Critical thinking skills have been clear as a skill of attractive charge and switch of our particular attention (e.g. Mabruroh & Suhandi, 2017; Rahim et al., 2019; Aminudin et al., 2019; Bhakti et al., 2019; Malhotra, 2019), otherwise it as a rational and thoughtful skill supposed which emphases on a result in what to accept as true.

Critical thinking is to a great extent wanted by students in the future, the essential know-how to sieve the right info as wanted (e.g. Mabruroh & Suhandi, 2017; Malik et al., 2018; Aminudin et al., 2019; Anu & Nair, 2019; Hassan

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et al., 2020). Critical thinking is one of the most significant skills in real life. Critical thinking mentions the capability to analyze data, regulate the significance of data collected, and interpret it to answer complications. In critical thinking, student answers are measured as stated by the heading of perceptive essentials explicitly determination, questions, material, position, conventions, ideas, assumptions, and insinuation.

Critical Thinking Instrument Test (CTIT) is a multiple choices instrument that used the indicator based on Ennis' critical thinking aspect (Ennis, 1985; Ennis, 2015). Critical thinking skills must be supported by a measuring instrument that can measure such abilities. Measurement is a significant factor in education because, through the measurement, the teacher would be known accurately were students at one time in a movement (e.g. Carni et al., 2017; Siahaan et al., 2017; Setyadin et al., 2019). Based on preceding research the obtainability of measurement tools that can be used as strategies indecisive the level of critical thinking skills of students, especially in the subjects of physics is infrequently (e.g. Hermawan et al., 2017; Bhakti et al., 2019). While, critical thinking skills test instrument needs to be developed in all the subjects of physics (Mabruroh & Suhandi, 2017; Rahim et al., 2019). However, these instruments were still analyzed using usually statistics analysis, and there are infrequently researchers who have developed instruments to measure students' Critical Thinking using new modeling such as Rasch analysis.

The Rasch analysis was initially made by Georg Rasch in 1960 to test building in psychology with two types of strictures, a difficulty for a separate item and a capability for each person (e.g. Masters, 1982; Tesio, 2003; Aminudin et al., 2019). Raschf analysis is a statistical method for describes the collaboration of persons with test items that can be understood as a psychometric tool in social science and it has strong measurement properties (e.g. Joyce & Yates, 2007; Lim et al., 2009; Chan, Ismail, & Sumintono, 2014; Brandt et al., 2015; Sumintono, 2018; Planinic et al., 2019; Adimayuda et al., 2020; Purwanto et al., 2020).

Indonesia is famous to have numerous tribes and cultures (e.g. Ananta et al., 2013; Aminudin et al., 2019; Adimayuda et al., 2020). Classified 15 largest tribes in Indonesia they explained that five of the fifteen largest tribes instigated from the Island of Java one of which was the Sundanese, the second-largest tribe after the Javanese (Aminudin et al., 2019). Some features in the Sundanese are the call for boys with "*pameget*" and girls with "*istri*". Thus, the dialog of the Sundanese is an exciting thing to discuss, especially in the field of education.

Based on that background, the research purposes to develop and analyze instrument tests for critical thinking skills and for physics concepts on fluid static which have been divided into three sub-concepts which are Hydrostatics, Pascal Law, and Archimedes Law (Purwanto et al., 2020). The development of this instrument, namely (Critical Thinking Instrument Test), is very important because indicative instruments to test the students' conception are still infrequently to find. This instrument is developed based on Ennis Indicator are Basic Clarification, Bases for a Result, Interpretation, Development Clarification, Supposition, and Integration (e.g. Ennis, 1985; Ennis, 2015; Purwanto et al., 2020).

II. Method

Research Design

The method that used in this study is the ADDA method which has four relatively comprehensive steps that are analyzed, design, develop, and applied. In analyzing stage, the process used is to analyze the critical thinking indicator based on Ennis' critical thinking feature, the program that used and thought depth. On design and development, stage researchers considered the format and example of question CTIT. Furthermore, the instrument that has been developed

before was Application to the students. Finally, all students' response was analyzed through students and score using Rasch analysis.

Participants

The participants of this research are the 10th-grade high school students who are locating in Cibeureum, Tasikmalaya. These respondents consist of 9 males who called "*pameget*" and 11 females, namely "*istri*". Figure 1 shows the location of Cibeureum.

Figure 1. Cibeureum sub-district map Tasikmalaya City

Data Analysis

The data of response was used to examine the quality of instruments including person reliability, item reliability, validity, difficulty level, person item, and Cronbach alpha All the data entered into Microsoft Excel which reformed the students' response became the binary code. Then, the binary code inspected using Rasch analysis through WINSTEP software version 4.4.5 (Purwanto et al., 2020).

Instrument

The instrument utilized in this research is the Critical Thinking Instrumen Test (CTIT) which consists of fluid static such as Hydrostatics, Pascal Law, Archimedes Law. However, the question type of CTIC is multiple choice. The CTIT consists of 10 items and one of the examples of the item can be seen in the Figure 4.

III. Results and Discussion

The result and discussion will be discussed through the ADDA model, which consists of analyze, design, develop, and applicate as follows:

Analyze

The analyze stage, the way that used is to analyze the critical thinking indicator based on Ennis' critical thinking aspect (Zhu & Han, 2011), the program that used, and thought depth. The critical thinking indicators that applied defined in Table 1.

Table 1

The relative of critical thinking and indicator that used

Critical Thinking Domain	Indicator
Basic Clarification	Finding the standards of probable response
Bases for a Result	Finding cause or grounds
Interpretation	Explaining the suggestions
Development Clarification	Defining the scientific period and seeing the descriptions
Supposition and Integration	Choosing the probable standards as a key to the problems

Furthermore, researchers have conducted some literature studies on several previous types of research (e.g. Purwanto et al., 2018; Purwanto et al., 2020), that have been occurred on fluid statics. Furthermore, we also scrutinized the objectives of static fluifd material on the curriculum 2013 in Indonesia. Finally, we found there are at least three sub-concepts on this material which are hydrostatic, Pascal law, and Archimedes law (Purwanto et al., 2018; Purwanto et al., 2020).

Design

In the next level of ADDA, we have built the CTIT items on fluid statics concepts. After analyzing sub-concepts and the relative of critical thinking and indicator, researchers design the format. The first CTIT of the questions is the main multiple-choice that should be solved by the respondents. For more detail, the format can be shown in Figure 2.

Critical Thinking Domain :
Basic Clarification

Sub Concept :
Hydrostatics

Indicator :
Finding the standards of probable response

Question :
Differentiating the hydrostatic pressure at various points/depths on vessels

Answer Choice :

A. Choice 1
B. Choice 2
C. Choice 3
D. Choice 4
E. Choice 5

Figure 2. Design CTIT

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Develop

The items of instruments were designed in the develop stage. The distribution of items on an instrument to each Critical Thinking Skills indicator and thought explanation is assumed in Table 2.

Table 2

Distributions amount of CT skills indicator with thought explanation

Indicator	Hydrostatic Pressure	Pascal's Law	Archimedes' Law
Finding the standards of probable response	1	1	1
Finding cause or grounds	1	-	1
Explaining the suggestions	-	1	-
Defining the scientific period and seeing the descriptions	1	1	-
Choosing the probable standards as a key to the problems	1	-	1

Figure 3 is an example of the instrument used to measure critical thinking skills as follows.

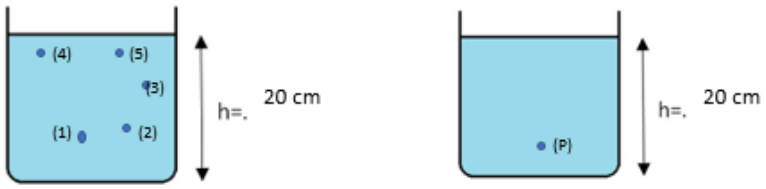
Aspect Critical Thinking :

Basic Clarification

Indicator Critical Thinking Skills :

Finding the standards of probable response

Test :



In the 2 bowls above each covers a liquid whose mass ratio $\rho A : \rho B = 5 : 4$ species. The point of bowl A which has a pressure equal to the point P on bowl B is the point....

A. (5), h_2 = 8 cm
B. (4), h_4 = 10 cm
C. (3), h_3 = 12 cm
D. (2), h_2 = 16 cm
E. (1), h1 = 20 cm

Figure 3. Example of Fluid concept critical thinking test item that was developed

Applicate

Afterward, the developing stage of the instrument done, the next stage is applied. On the applicate stage, the instrument test is tried to measure the student's CT skill sample to get its quality of instrument including person reliability, item reliability, validity, difficulty level, gender item functioning, and Cronbach alpha. Subjects who used the probationary of these things are the 10th-grade students one of the Senior High School at Cibeureum Tasikmalaya city. The resulting charge is associated with a reliability person with the Rasch model in Figure 4.

SUMMARY OF 26 MEASURED Person

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	6.2	10.0	.87	.94	.96	-.10	1.07	.15
SEM	.4	.0	.34	.02	.11	.23	.38	.19
P.SD	2.1	.0	1.68	.11	.57	1.15	1.91	.97
S.SD	2.1	.0	1.71	.11	.58	1.17	1.95	.99
MAX.	9.0	10.0	3.48	1.23	2.48	2.51	9.90	4.03
MIN.	1.0	10.0	-3.38	.85	.38	-1.65	.13	-.86

REAL RMSE	1.04	TRUE SD	1.31	SEPARATION 1.25	Person RELIABILITY	.61
MODEL RMSE	.95	TRUE SD	1.38	SEPARATION 1.46	Person RELIABILITY	.68
S.E. OF Person MEAN = .34						

Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .70 SEM = 1.18

Figure 4. Summary of Reliability Person with the Rasch Model

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According to Figure 4, it can be seen of person reliability .61 and .68, which the reliability for person is involved in 'good category. it means that the instrument is reliable and could applicate to measure the students' critical thinking skills on static fluid. Furthermore, The quality of interaction between the person and items illustrated by Cronbach Alpha value (KR-20) of .70 is involved in the 'good' category. Then, the resulting charge is associated with a reliability item test with the Rasch model in Figure 5

SUMMARY OF 10 MEASURED Item

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	16.0	26.0	.00	.61	.98	-.04	1.43	.11
SEM	2.2	.0	.66	.04	.08	.30	.66	.35
P.SD	6.7	.0	1.99	.13	.25	.90	1.98	1.06
S.SD	7.1	.0	2.10	.14	.26	.94	2.08	1.12
MAX.	24.0	26.0	3.69	.85	1.26	1.25	7.22	2.70
MIN.	3.0	26.0	-2.71	.48	.57	-1.83	.20	-1.42
REAL RMSE	.66	TRUE SD	1.88	SEPARATION	2.86	Item	RELIABILITY	.89
MODEL RMSE	.62	TRUE SD	1.89	SEPARATION	3.03	Item	RELIABILITY	.90
S.E. OF Item MEAN = .66								

Figure 5. Summary of Reliability Person with the Rasch Model

According to Figure 5, it can be seen of item reliability .89 and .90, in which the reliability for the item is involved in the "Very Good" category. These mean that the instrument is reliable and could applicate to measure the students' critical thinking on static fluid.

On the other hand, the result of item validity and distinction level on each item are shown in the Table 3. This data was measured using WINSTEP 4.4.5 software through Item (column) output: fit orders (Purwanto et al., 2020). The value of MNSQ and ZSTD are considered to decide whether the items are valid or not, while the score of PT Measure-All core are analysed to examine the distinction level (Purwanto et al., 2020).

Table 3

The interpretation of item validity and distinction level

Cub Concepts	Question Number	Outfit		PT Measure-All Corr.	Interpretation (item validity)	Interpretation (Distinction Level)
		MNSQ	ZSTD			
Hydrostatics	1	1.81	.97	.35	Valid	Good
	2	.57	-.12	.41	Valid	Very Good
	3	.64	-.53	.63	Valid	Very Good
	4	.50	-.41	.57	Valid	Very Good

Cub Concepts	Question Number	Outfit		PT Measure-All Corr.	Interpretation (item validity)	Interpretation (Distinction Level)
		MNSQ	ZSTD			
Pascal Law	5	7.22	2.70	.12	Not Valid (Need Revision)	Insufficient
	6	1.03	.33	.46	Valid	Very Good
	7	1.10	.37	.39	Valid	Very Good
Archimedes Law	8	.43	-1.42	.79	Valid	Very Good
	9	.64	-.62	.67	Valid	Very Good
	10	.83	-.14	.60	Valid	Very Good

Based on Table 5, it is clear that nearly all of the items are valid to use, except the item number 5 which desired minor revision. This is because the MNSQ value surpasses the maximum standard which is 1.5 (Purwanto et al., 2020). Thus, this item involves a minor revision because the MNSQ value is not too far from the standard. In line with validity, the difference level shows the predictable results (Purwanto et al., 2020).. All of the items are involved in the categories of ‘very good’ and ‘good’, though there is one item that involves the 'insufficient’ and must be revised or changed (Purwanto et al., 2020)..

One of the requirements for the instrument that can be said as a "valid instrument" is the difficulty level of the items should be regularly distributed. Therefore, the researchers also scrutinized the difficulty level of the instrument. This analysis has done through a Bubble chart on WINSTEPS 4.4.3, as the tools of Rasch analysis. The analysis of these steps can be shown in the Figure 6.

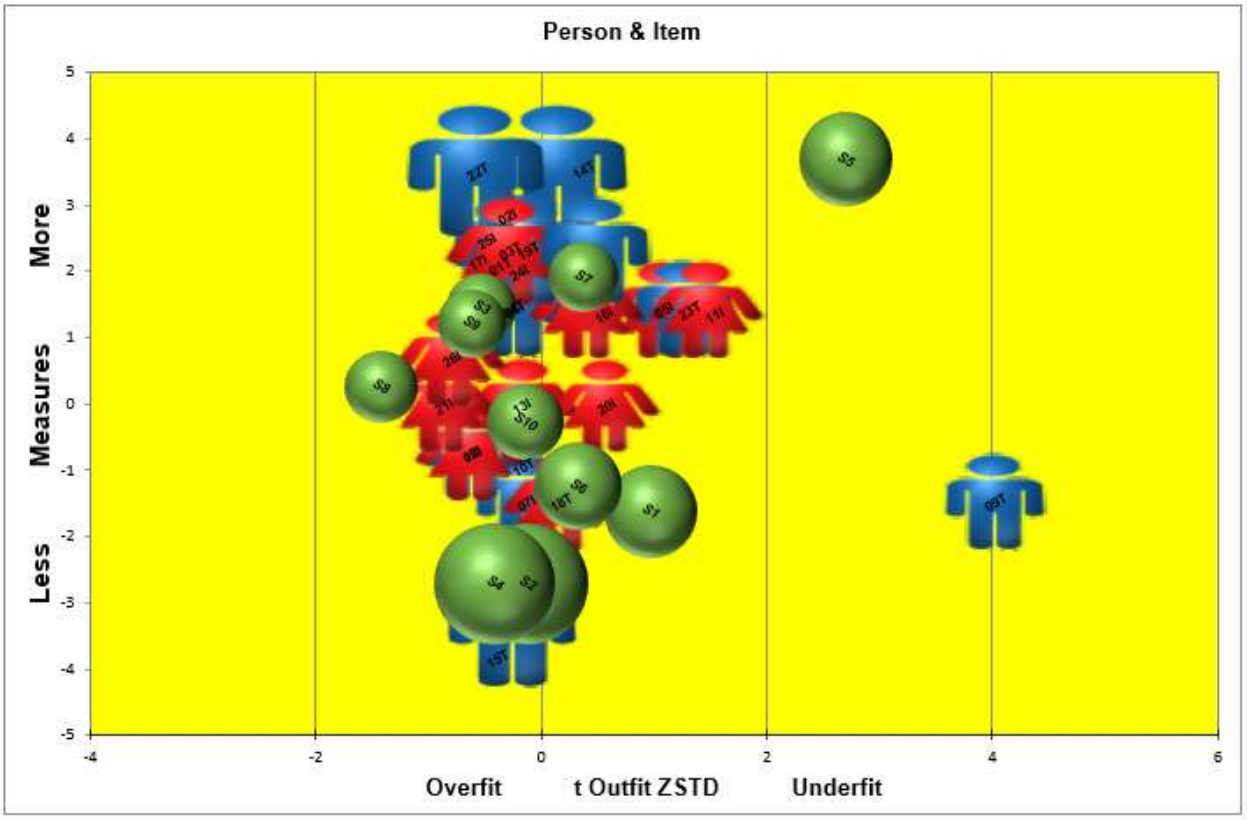

Figure 6. Person and Item Difficulty Level

The Information codes of item and person in Figure 6 can be shown in Table 4.

Table 4

Code of item and Person Item Difficulty Level

Code	Symbol	Information
T		Male
I		Female
S		Question

According to the figure 6, it can be seen that the students' with the ability of 26 person, the symbol 'T' (means '*Pameget*' or male) and the symbol 'I' (means '*Istri*' or female) shows that the number of the students' 22 T and 14 T are the highest critical thinking abilities. While students with the lowest critical thinking are the number 15 T and for the hardest item difficult is S5.

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Besides the analyses above, the difficulty level is also scrutinized to see the quality of instruments. The standard value of this analysis based on the value of Standard Deviation (SD) that increased from the analysis. The value of the Standard Deviation (SD) gotten is .80, so that the category of difficulty level in each question can be analysed using the SD. A value of.00 logit +1 SD is a difficult category, greater than + 1SD is a very difficult category, .00 logit -1SD is an easy category and smaller than -1SD is a very easy category (e.g. Weiss, 2013; Carni et al., 2017; Purwanto et al., 2020). This shows that there are four clusters of difficulty level in the instrument (very difficult, difficult, easy, and very easy).

Based on the category above, the difficulty level of each item in the instrument is as follows in the Table 5.

Table 5

The difficulty level on each item

Sub Concepts	Question Number	Measure	Difficulty Level
Hydrostatic	1	-1.62	Very Easy
	2	-2.71	Very Easy
	3	1.45	Very Difficult
	4	-2.71	Very Easy
Pascal Law	5	3,69	Very Difficult
	6	-1.23	Very Easy
	7	1.91	Very Difficult
Archimedes Law	8	.26	Difficult
	9	1.22	Very Difficult
	10	-.27	Easy

Looking at Table 5, we can see that the difficulty level of the question is regularly distributed. There are items that involved in the category of very difficult, difficult, easy, and very easy. This shows that the difficulty level of the items on the CTIT instrument is highly distributed. The other analysis relates to the score of students shown in Figure 7.

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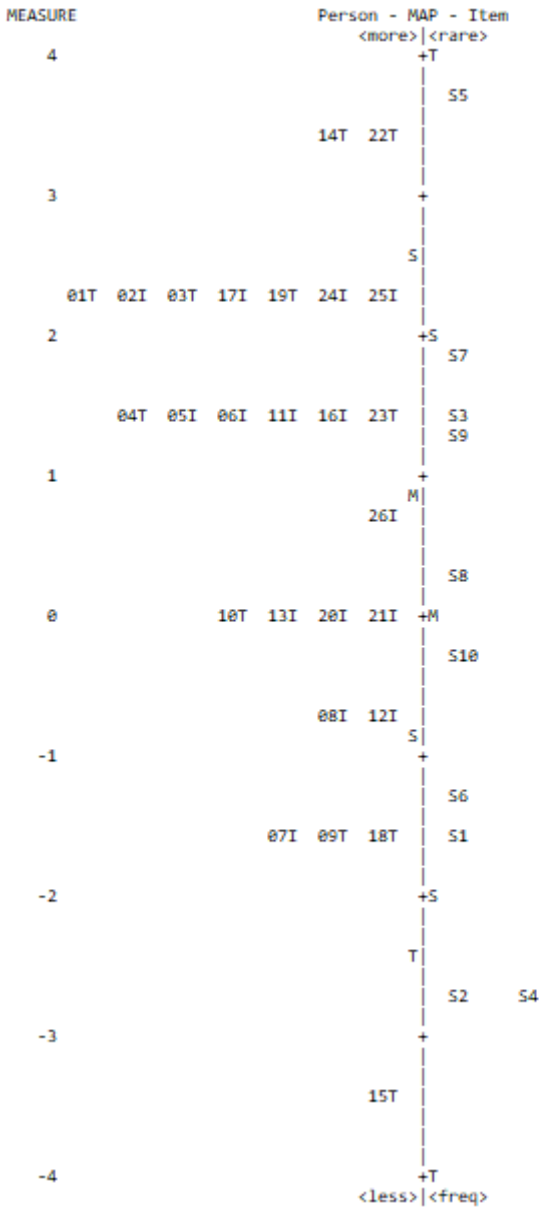

Figure 7. The score of Students in Wright Map

On the left side is a feast of subject abilities, while on the right is a distribution of items. From the map, it can be seen that in general the questions in the test are more difficult when compared with the ability of the subject. The most difficult item is item number S5 which is in the top position. Hypothetically with that problem no subject will have a chance to answer the problem correctly because it has a lower ability than the difficulty level of the problem.

The score of students shows the students of 14 T and 22 T (*Pameget* or Male) have the highest ability and the lowest ability is 15 T (*Pameget* or Male). However, despite the highest ability of 14 T and 22 T below S5 (Question 5). While 15T, their abilities under all questions. The questions with the lowest are S1 and S4, hence students with the ability below are certainly not able to answer all the questions (Aminudin et al., 2019).

One of the supplies for the instrument to be valid is that the instrument and items used do not comprehend bias (Weiss, 2013; Purwanto et al., 2020). An instrument is called bias if it is found that one individual with certain characteristics is more valuable than others. For example, items are more easily answered by male students than women which means the instrument is suffering gender bias. In line with this, the researchers have done gender differential item

functioning calculations using DIF output on WINSTEP 4.4.5 software (Purwanto et al., 2020). The result of bias analysis is shown in Figure 8.

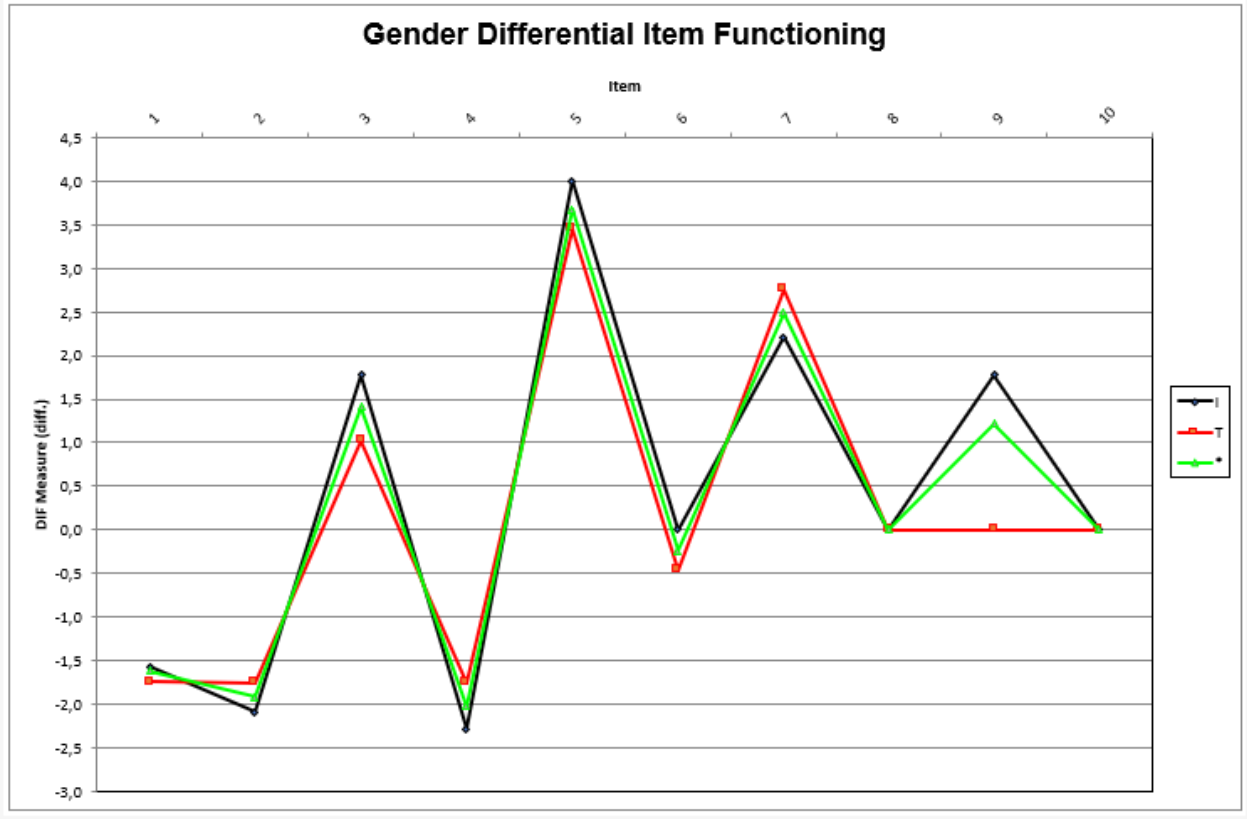

Figure 8. Gender Differential Item Functioning

Based on the information in the Figure 8, we can see that the curve approached the upper limit (such as item number 5), shows a high level of difficulty, while the curve below (such as item number 4) shows an easy level of difficulty. Besides, we can conclude that the majority of questions do not experience gender bias, except question number 9. The 'T' curve (means '*Pameget*' or male) with the 'I' curve (means '*Istri*' or female) has a fairly wide range. It seems that this item is easier answered by 'T' rather than 'I'. So, this item needs to be done a minor revision

IV. Discussion

ADDA model was carried out to develop the Critical Thinking Instrument Test (CTIT). In order to develop the instrument, researchers have done analysing stage to quantity up the current condition associated to students' critical thinking (Hidayat et al., 2019). This analysis was associated with the current curriculum in Indonesia, which is the 2013 curriculum and shows the critical thinking aspect with indicators (Purwanto et al., 2020). Based on the result of the analysis stage, researchers designed an instrument that can be used to measure the students' critical thinking. Finally, CTIT was decided to use in this research. After that stage, the CTIT design and develop the show in Table 2 and Figure 2. After that, CTIT was applied to 26 students' that come from Cibeureum Tasikmalaya city in West Java. Then, the data was analyzed using Rasch analysis to test its validity, reliability, person, and item difficult on the bubble chart.

Based on Figure 4 and Figure 5 it can be seen of person and item reliability for a person is involved in a 'good category and 'very good' category. The quality of interaction between the person and items illustrated by Cronbach Alpha value is involved in the 'good' category. It is important to see the consistent performances on students and assimilate with the exactness of a convinced measurement which can be interpreted based on reliability value (e.g. Romine & Sadler, 2016; Mešić et al., 2019; Purwanto et al., 2020; Samsudin et al., 2020).

Based on Table 5, it can be concluded that all of the items in the CTIT instrument are valid to use. This is in accordance with (e.g. Arsad et al., 2013; Adams et al., 2018; Park & Liu, 2019; Purwanto et al., 2020; Samsudin et al., 2020) study that the valid items on instrument had to be fit on the value of 0,5 < MNSQ < 1,5 and -2,0 < ZSTD <+2,0. Thus, all items on the SFCI are valid, except number 5 which needs minor revision because the MNSQ score is out of the required value. However, the score is not too fat from the required value, so that the item just needs minor revision.

As mentioned above, the appropriate instrument is not only needed to be valid but also balanced difficulty (Purwanto et al., 2020). Likewise, the good instrument should have changed of difficulties and proportionate difficulty (e.g. Zhu & Han, 2011; Mešić et al., 2019; Purwanto et al., 2020). In line with that, the researchers happened difficulty level analysis as the results can be shown in Figure 6 and figure 7. From the Figure 6 and figure 7, it can be seen that students with the ability of 26 person. Two persons were the highest critical thinking abilities and one person was the lowest critical thinking abilities and one item for the hardest difficulty and there is a wide range between two samples, "*Pameget*" and "*Istri*", and must be revised. In line with that, the researchers occurred difficulty level analysis as the results can be shown in Table 6. From the table, it can be seen that the difficulty levels are shared proportionally in each item. There are four items which involve in the 'easy' and 'difficult categories, respectively, while there are two items which decided to be 'very easy' and 'very difficult' categories, respectively. It means that the difficulty level of the question is regularly distributed.

To make sure that the instrument did not contain bias, the researchers have done a DIF analysis through Rasch Analysis. This purpose is to make sure that there is no individual with certain characteristics is more advantageous than others (Boone et al., 2014). The characteristics that have been scrutinized in this research is gender. From Figure 8, we can see that most items do not experience gender bias, apart from item number 5. There is a wide range between two samples, *'pameget*' and '*istri*', and must be revised. so, the question needs to be done a minor revision.

V. Conclusion

Based on the development and trial test of developed Critical Thinking Instrument Test (CTIT), it can be concluded that the use of an instrument to measure the students' critical thinking is categorized as valid and reliable. These results can be seen from the test results that applicated to 26 students from the Cibeureum region Tasikmalaya city West Java. These results show that the Critical Thinking Instrument Test (CTIT) can be used as a reference for additional research by researchers as well as by teachers in order to carry out the learning process and measure critical thinking on Static Fluid concepts.

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