Develompemnt Electronic Four Tier Diagnostic Test Based Multirepresentation Using Model 4-D For Measuring the Level of Conception of Prospective Physics Teacher Candidates on Force Concepts

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Abstract- This study aims to develop instruments electronic four tier diagnostic test (E-FTDT) use the Google Form to measure the level of student teachers conception of physics (MCGF) on the concept of style. Development uses a 4-D model that consists of define, design, develop, and disseminate. Validation was carried out for three material experts and three media experts, small-scale trials were conducted at 15 MCGF, and large-scale tests were conducted at 36 MCGF. The result of material expert validation was 85% with A value, media expert was 89.39% with A value, and MCGF response on small scale test was 80.20% with B value. Based on a large-scale test showed that the percentage level MCGF conception, namely; understand the concept well by 17%, to understand the concept, but less convinced by 3%, to understand the concept. But not a whole by 16%, do not understand the concept of 14%, and misconceptions by 47%, and there is an answer that can not be encoded by 3%. The conclusion of this study explains that E-FTDT is feasible to use and has the potential to measure the level of MCGF conception in the concept of force.

Index Terms- Diagnostic Test, Conception Level, 4-D Model, Style.

I. INTRODUCTION

In physics, the right concept refers to conception as physics scientists. Misconceptions that improper or different from the concept of the scientists called misconceptions. Misconceptions can be caused by several factors, including experience, teachers, teaching materials, and learning media are involved in the learning process [1]. In addition, the use of non-standard language into one the obstacles that led to the concept of physics is difficult to read by the students [2]. Misconceptions in science lessons focused on potential areas of physics happen because of some abstract concept [3]. Misconception occurs in all areas of physics, from 700 studies on alternative theories of physics, there are 300 who studied the misconceptions in mechanics; 159 on electricity; 70 about heat, optics and material properties; 35 about earth and space, and ten studies about modern physics [4]. These data show that the mechanics are a field of physics most experienced misconceptions..

Force is one of the concepts in mechanics that is most tested [5-7]. It means that this concept also has great potential in the occurrence of misconceptions. It is consistent with research showing that most college students have misconceptions on the concept of style [8-11]. In line with this, three international seminars have been held at Cornell University, Ithaca, New York, USA in 1981, 1987 and 1993 by presenting papers totalling more than 600 titles, which are based on research and theories on how to help eliminate misconceptions. Various techniques can be used to identify misconceptions in students of them are using concept maps, multiple-choice test with open grounds, a written essay test, diagnostic interviews, discussion in the classroom to practice questions and answers[12].

One tool that often used to evaluate learning is a diagnostic test. The diagnostic test is a test used to determine the weaknesses of learners so that based on these weaknesses can be given the appropriate treatment [13]. The diagnostic test can improve learning outcomes and can overcome learning difficulties and reduce misconceptions learners. The purpose of this test is to determine the teaching that needs to be done in the future [14]. It is supported by research showing that the use of diagnostic tests can provide information about the level of understanding of the concept [15].

There are four types of the diagnostic tests data rate of up to four levels. But the diagnostic test that is most capable of providing a clear picture of misconceptions in students is a four-level diagnostic test [16-17]. The first level is multiple choice questions with four deceivers and an answer key. The second level is the level of confidence in the answers at the first level. The third level is the reason that must be given in answering questions at the previous level. The reasons provided are open.

While the fourth level is the level of confidence in the reasons given at the third level. In some studies, the mostly four-tier diagnostic test still non-electronic form, which usually presented in the form of paper/sheet [11,17,18,19]. Some of the difficulties arising from a test like this are during the process of examination answers learners; proofreader sometimes experiences problems such as difficulty in writing illegible students perfect and human-error factor of the corrector itself. In addition, other obstacles that also arise are that much paper is needed, securing the confidentiality of questions is relatively tricky. It requires a large amount of money, processing the results requires a relatively long time, especially for the use of diagnostic tests. Therefore, these tests are then modified form of a electronic four tier diagnostic test .

In line with this, the development of information and communication technology (ICT) era of the industrial revolution 4.0 is now increasingly complex and evolving. We are required to be more competitive with the times so that in this case the implementation of the research will make it possible for learners to more easily work tests and make it easier for researchers or teachers too in examining the results of these tests. It is in line with the results of research suggest that the use of ICTs such as the Internet or a computer will make it easier in terms of both effectiveness research or efficient [20,21]. One feature that is often used and is familiar to the broader community are Google, Google Form. This feature is one of the highlights of Google that allows one to make a reliable evaluation test sheet, and also in its implementation will be more effective and efficient [22]. Some research indicates that the use of a Google Form as an electronic instrument in the study is very useful in helping and facilitate analysis or assessments performed in an agency for practical, free, and easy to use [23, 24].

Instruments developed in this research instruments adopted from the paper entitled Representational of the Force Concept Inventory (R-FCI) [25]. R-FCI is a development of the instrument Force Concept Inventory (FCI) [26]. R-FCI is an instrument that has been standardized and designed to assess the students understanding of the basic concepts of physics that deals with forces and motion. R-FCI is also a concept test standard for mechanics that have proven validation and reliability and have been used repeatedly in different countries. However, this instrument cannot be used to diagnose student conception levels because the format is in the form of multiple-choice questions so that it only tests student conceptions. Therefore, researchers developed it into a test instrument to diagnose potential student conception level. In the instrument, there are 27 items with multiple choice about the concept of force (Newtonian Mechanics) with nine themes, each theme consisting of 3 representations. The concept in the theme ninth consecutive test on; (1) gravitational force, (2) Newton's third law, (3) Newton's second law, (4) gravitational force, (5) Newton's first law, (6) Newton's second law, (7) Newton's first law, (8) Newton's third law, and (9) gravitational force [25].

The level of confidence that is presented on the second and fourth-tier in these diagnostics tests using methods Certainty of Response Index (CRICRI is a method used to measure the level of confidence/assurance respondent in answering each question/questions provided. Respondents asked to provide the level of certainty of their ability to associate a confidence level with the knowledge, concepts, or law [27]. It is possible to minimize the guesswork out of student answers due to the shape of the FCI only multiple-choice only. It is supported by the results of research which states that the CRI method can be used to identify students' misconceptions and who do not know the concept. In addition, its use in the teaching and learning process is possible because the process of identifying and analyzing the results does not take a long time [19,28].

However, the methods that have been prepare have weaknesses. Weakness contained in this method lies in the categorization, which has a low confidence level, and the amount of guess factor in answering the question because of the form of items used are multiple-choice tests. The presence of the actual respondents characterizes it was able to explain and understand the concepts contained in the matter. But because it has a low level of confidence led him to choose a small CRI scale, so it divided into categories does not understand the concept / deemed to guess the answer. By considering this condition, the category of the understanding level that has been compiled is then modified by adding a category that is understanding the concept but not sure [29]

II. METHOD

This research is a Research & Development study that aims to produce a product and test the feasibility of the product [30]. This study uses a model development procedure 4-D [31]:

1. **Define**
   This stage includes field studies and literacy. The field study aims to obtain information about the implementation of physics learning in class and information about the characteristics of prospective physics teacher students — literacy studies conducted to assess the relevant concepts and related studies. The results are used as material to identify problems in learning activities.
2. **Design**
   After getting the problem and information from the definition phase, then performed the design stage. The purpose of this stage is to produce an E-FTDT design that can be used to measure the level of conception of prospective physics teacher students on the concept of force. This designs first made input from the supervisor. This feedback will be used to repair instruments developed before entering the next stage
3. **Develop**
   a. Expert Validation

The purpose of this validation to get an assessment of experts are competent in the development of the instrument. In addition, to take input so that the instruments developed are better. The data analysis was done by tabulating data obtained from the results of expert validation for every aspect of the assessment items based research instruments. Data analysis was conducted referring to the calculation formula (1) and the following eligibility criteria.

$$\bar{x} = \frac{\Sigma x}{n} \quad (1)$$

Where:
$\bar{x}$: Average score
Σx : Score total
n : Number validator

The assessment of product development is carried out in the form of scores. Assessment by the quantitative data obtained from the scoring converted into qualitative data that consists of five categories. The conversion process is done with the formula contained in the following Table 1. [32].

Table 1. Conversion into a quantitative score qualitative score

Score Scale	Score	Category
$x > \bar{X} + 1{,}80\,SBi$	A	Very good
$\bar{X} + 0{,}60\,SBi < x \leq \bar{X} + 1{,}80\,SBi$	B	Good
$\bar{X} - 0{,}60\,SBi < x \leq \bar{X} + 0{,}60\,SBi$	C	Good enough
$\bar{X} - 1{,}80\,SBi < x \leq \bar{X} - 0{,}60\,SBi$	D	Poorly
$x \leq \bar{X} - 1{,}80\,SBi$	E	Not good

Where:
$\bar{X}$: Average score $= 1/2$ (ideal maximum score + ideal minimum score)
SBi: ideal standard score $= 1/6$ (ideal maximum score - ideal minimum score)
x : average score

The feasibility of the product is determined by the value of at least C with a category quite well. Thus, if the results of the expert judgment give the final result C, then this development product is considered suitable for use [32].

b. Limited trial

Tests carried out is limited to 15 student teachers of physics. Analysis of the results of diagnostic tests in a limited test is also based on the calculation formula (1) and assessing the feasibility of the development of products in Table 1

4. Disseminate

After validation by experts and a limited test and the instrument has revised, the next stage is the stage of dissemination. The purpose of this stage is to disseminate the E-FTDT instrument that has been developing to be used as an evaluation instrument in measuring the level of conception of prospective physics teacher students on the concept of force. This process was carried out at the large-scale trial stage with 36 MCGF respondents. The analysis of the results of this stage is guided by the modification of the conception level categories as in Table 2 below [29].

Table 2. Modification of the conception level category

Answer Combination				Description	Code
Tier-1	Tier-2	Tier-3	Tier-4		
Benar	CRI > 2,5	Benar	CRI > 2,5	Understand the concept well	PK
Benar	CRI > 2,5	Benar	CRI < 2,5	Understanding the concept but not sure	PKKY
Benar	CRI < 2,5	Benar	CRI > 2,5		
Benar	CRI < 2,5	Benar	CRI < 2,5		
Benar	CRI > 2,5	Salah	CRI > 2,5	Understanding the concept but not intact	PKTU
Benar	CRI > 2,5	Salah	CRI < 2,5		
Benar	CRI < 2,5	Salah	CRI > 2,5		
Benar	CRI < 2,5	Salah	CRI < 2,5		
Salah	CRI > 2,5	Benar	CRI > 2,5		
Salah	CRI > 2,5	Benar	CRI < 2,5		
Salah	CRI < 2,5	Benar	CRI > 2,5		
Salah	CRI < 2,5	Benar	CRI < 2,5		
Salah	CRI > 2,5	Salah	CRI > 2,5	Misconception	M
Salah	CRI > 2,5	Salah	CRI < 2,5	Don't understand the concept	TPK
Salah	CRI < 2,5	Salah	CRI > 2,5		
Salah	CRI < 2,5	Salah	CRI < 2,5		

Answer Combination				Description	Code
Tier-1	Tier-2	Tier-3	Tier-4		
There is a combination of answers that are not appropriate.				Cannot be encoded	TDK

CRI scale used is based on a scale according to Table 3 below [28].

Table 3. CRI Scale

Scale	Category	Code
0	Totally Guess Answer	BBT
1	Almost Guess	AT
2	Not Sure	TY
3	Sure	Y
4	Almost Sure	AY
5	Certain	SY

III. RESULT AND DISCUSSION

1. Define

In this stage of the discussion with the supervisor obtain information about physics teaching. In the classroom as well as the characteristics of physics student teachers who will serve as the respondent in a limited test. Based on these discussions shows that learning in the classroom generally been going well in which a student equipped with the physic sciences and science education. But they rarely do an evaluation of the level of conception owned the physics student teachers.

The results of the discussion also showed that student teachers of physics the most suitable as the respondents are students who will conduct teaching practice in schools that practice VI semester students. In addition to the knowledge of physics, especially on subconcepts particle kinematics have been obtained on the basic physics course, they also provided academic about education/teaching and have made micro-teaching practice as a first step before plunging into the field directly. so that if after the tests are limited and there is an indication that the student does not understand the concept or even occur misconceptions will be immediate remedial action.

2. Design

Before development, the initial design of the instrument can be seen in Figure 1 below.

Instrumental Identity

Identity of Respondents

Work instructions

Question to – n

Multiple selected items in question to – n
A. (*Answer choices 1*)
B. (*Answer choices 2*)
C. (*Answer choices 3*)
D. (*Answer choices 4*)
E. (*Answer choices 5*)

Figure 1. *Initial design of diagnostic tests before development*

After operating through a defining phase, the draft produced by advice that has been given is like Figure 2 below.

Instrumental Identity

Identity of Respondents

Work instructions
(Petunjuk Umum dan Khusus)

Question to – n

***n*.1** Multiple choice items
A. (*Answer choices 1*)
B. (*Answer choices 2*)

C. (*Answer choices 3*)
D. (*Answer choices 4*)
E. (*Answer choices 5*)

***n*.2** Your confidence level associated answers in Question *n*.1:
A. Very sure
B. Some sure
C. Sure
D. Not sure
E. Less Know
F. Really Don't Know

***n*.3** Your reasons are related to the choice of answers to the questions number *n*.1:
.....

***n*.4** Your level of confidence is related to the answer choices in the number *n*.3:
A. Very sure
B. Some sure
C. Sure
D. Not sure
E. Less Know
F. Really Don't Know

Figure 2. Design of four-tier diagnostic test development

One form of a question from a theme of the results of development carried out is as follows.

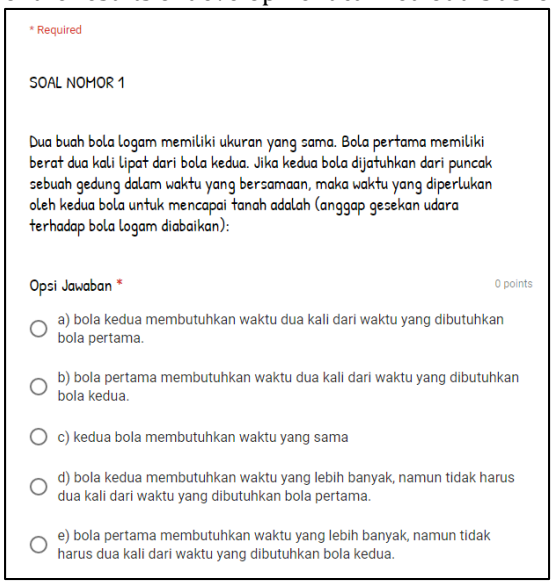
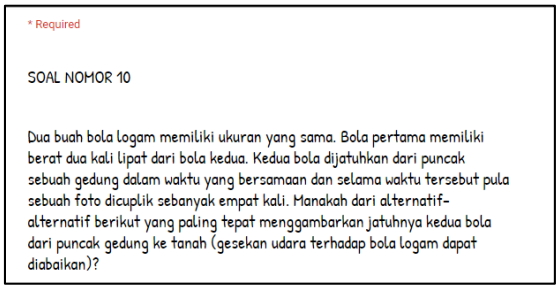


Figure3. The first-tier problem page is in the form of verbal representation

This page shows a way of delivering verbal shaped concept at the first tier.



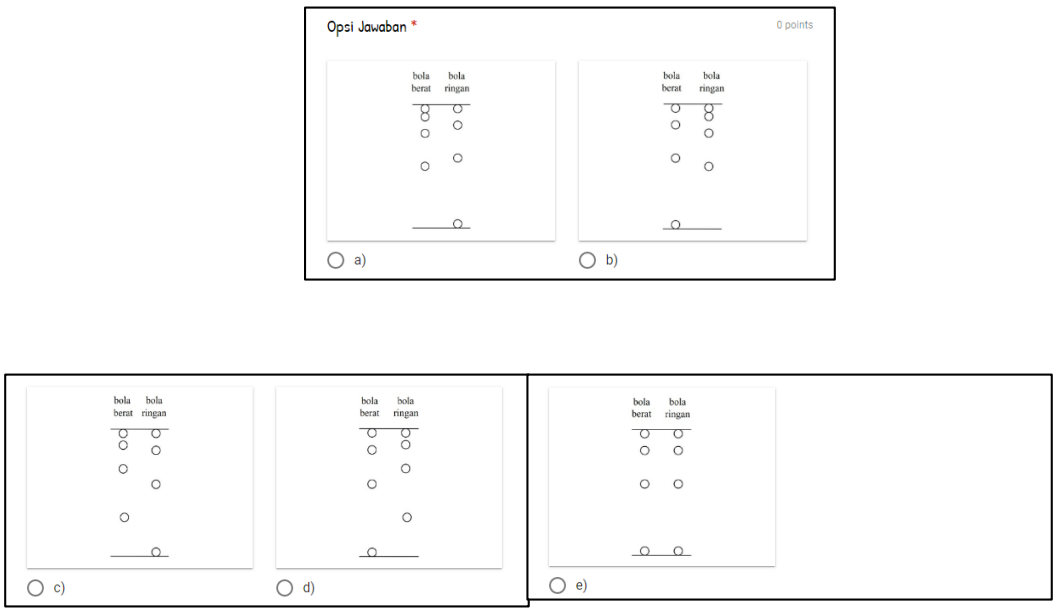


Figure 4. Page about the first tier representation shape drawing/diagram

This page shows a way of delivering shaped concept drawings/diagrams on the first tier

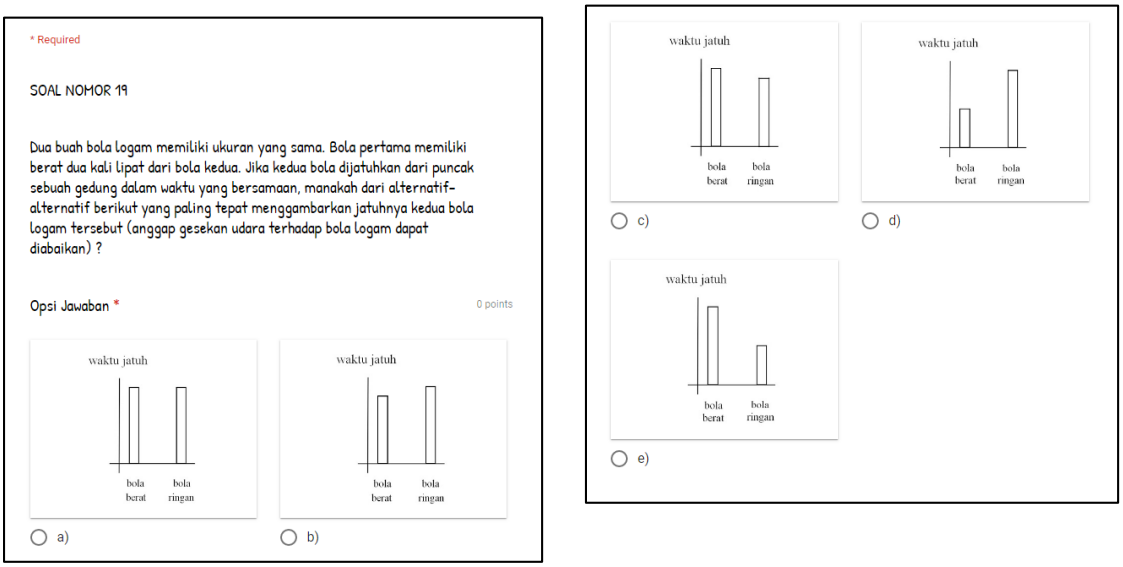
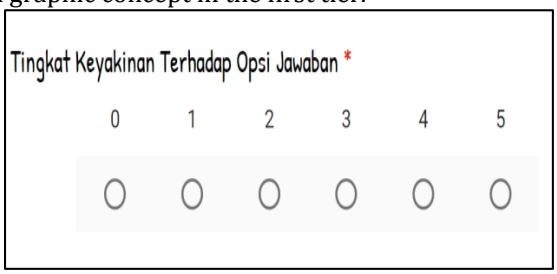


Figure 5. Problem pages with the first tier are graphical representations

This page shows a way of delivering a graphic concept in the first tier.



Gambar 6. Second tier

The second tier is the level of confidence of participants to answer selected in the first tier

Figure 7. Third tier

The third tier is the reason the answer given to the participants of the answers given to the first tier

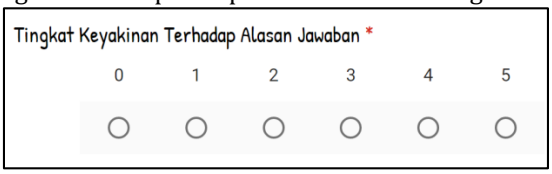


Figure 8. Fourth tier

The fourth tier is the level of confidence of participants to answer the reasons given in the third tier.

3. Develop

a. Expert Validation

The instrument validation developed involved three material experts and three media experts. The results of the validation by experts and media materials are presented in Table 4 and Table 5.

Table 4. The results of the material expert's validation of the E-FTDT

Assessment Aspects	∑ Per Aspect	∑ Ideal aspects	Percentage Assessment (%)	Value
Instrument instructions	33	36	91,67	A
Content	53	60	88,33	A
Presentation	46	48	95,83	A
Linguistic	27	36	75	B
Total	159	180	88,33	A

From Table 4, the results obtained from the material experts indicate that the average score of the developed test instrument as a whole is 159 (88.33% of the ideal score) with an A (Very good). It means that according to the three material experts, the developed test instrument categorized as suitable as a test instrument in measuring the level of conception of students of physics teacher candidates on the concept of force.

Table 5. Results of media expert validation on E-FTDT

Assessment Aspects	∑ Per Aspect	∑ Ideal aspects	Percentage Assessment (%)	Value
Instrument instructions	32	36	88,88%	A
Presentation	52	60	86,66%	A
Linguistic	34	36	94,44%	A
Total	118	132	89,39%	A

From Table 5 above, the results obtained from the material experts indicate that the average score of the developed test instruments as a whole is 132 (88.33% of the ideal score) with an A (Very good). That is according to the three media experts, developed test instruments categorized suitable as test instruments for measuring the level of the conception of physics student teachers to the concept of style.

b. Limited Tests

The results of the small-scale trials on the response of 15 MCG on E-FTDT presented in Table 6.

Tabel 6. Results MCGF response to E-FTDT

Assessment Aspects	∑ Per Aspect	∑ Ideal aspects	Percentage Assessment (%)	Value
Operation	187	240	77,92%	B
Content	151	180	83,89%	B
Display	235	300	78,33%	B
Linguistic	143	180	79,44%	B
Usefulness	102	120	85,00%	B
Total	818	1020	80,20%	B

Based Table 6, the results obtained from the MCGF response show that the average score of the developed test instrument as a whole is 1020 (80.20% of the ideal score) with a B (Good) score. It means that according to the MCGF, the developed test instrument is categorized as suitable to be used as a test instrument in measuring the level of conception of physics teacher candidates on the concept of force

4. Disseminate

Overall, the percentage ratio of the conception physics student teachers in the 27 questions that tested the concept of force can be interpreted in the following diagram.

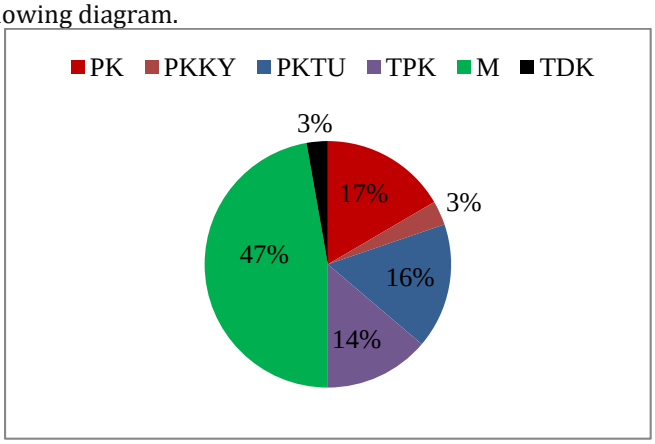


Figure 9. The percentage of conception MCGF diagram on the concept of style

The above results can also be presented based on detailed results on each theme so that it can be known the percentage of conceptions that occur in each of these themes. The results are presented in Table 7.

Table 7. Percentage of conception each theme

Thema	Percentage (%) of conception					
	PK	PKKY	PKTU	M	TPK	TDK
1.	16%	8%	9%	56%	9%	1%
2.	32%	1%	5%	45%	15%	2%
3.	20%	4%	23%	37%	12%	4%
4.	6%	3%	32%	35%	19%	6%
5.	4%	1%	19%	53%	23%	0%
6.	6%	0%	17%	65%	12%	1%
7.	15%	4%	26%	43%	8%	5%
8.	44%	2%	6%	33%	11%	3%
9.	6%	6%	10%	57%	15%	5%

From Figure 9, it is known that the most significant percentage of MCGF conceptions are misconceptions, where almost half of the total respondents tested. It turned out to be in line with Table 7, where the most significant percentage of conception that occurs in almost all themes are misconceptions. The biggest misconceptions occurred on six themes. Based on the answers given, actually, MCGF already understand the concept being tested but MCGF difficult to change their understanding in the form of questions that have representation in the form of map graphics and motion.

Correspondingly, it was found that the principal cause of misconception in most of the questions was the MCGF confidence level that exceeded 2.5 (CRI> 2.5) in the second tier and the fourth tier indicating that respondents had high confidence related to the correctness of the answers to the first-tier and third tier. The answer to the first tier or third tier indicated incorrectly. There are also respondents' answers that indicated as correct in the first tier but incorrect in the third tier.

This description, indicating that MCGF does not fully understand some of the concepts, Respondents only partially understand the concept without deepening it back so that respondents confused in choosing an answer or find it difficult to give a reason. It is then triggered many misconceptions of respondents labeled according to the response assessment criteria in Table 2. Thus it can be seen that the causes of the misconceptions come from his own self MCGF namely associative thinking, reasoning incomplete/incorrect, and intuition is wrong

From the analysis above, alternative solutions to solving misconceptions can be done with several tips to overcome misconceptions, including; confronted with reality, anomalous events, and rationality, as well as for incomplete/wrong reasoning can be completed[12].

IV. CONCLUSION

Based on the results of the study, it can be concluded that the developed test instrument answers both categories based on the results of the assessment by material experts, media experts, and MCGF responses on limited trials so that it is fit to be used as a test instrument and has the potential to measure the level of conception of prospective physics teacher candidates on the concept of force

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