



DEVELOPMENT OF FIVE-TIER INSTRUMENTS TO IDENTIFY STUDENTS' MISCONCEPTIONS ABOUT CENTRIPETAL AND CENTRIFUGAL FORCE

Maison^{1a)}, Jufrida^{2b)}, Widia Dina Oktavia^{2b)}

Universitas Jambi, Jl. Jambi-Muara Bulian No.KM.15, Mendalo Darat, Kec. Jambi Luar Kota, Kabupaten Muaro Jambi, Jambi, (0741) 583122

e-mail: ^{a)}widyaoktapia111@gmail.com

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ABSTRAK

The purpose of the study was to determine the development process and the feasibility of a five-tier diagnostic test instrument to identify students' misconceptions about centripetal and centrifugal forces. This research is a type of Research and Development (R&D) with the development model used, namely the 4D (Four-D) development model. This study uses the R&D method because the results of this study are in the form of a diagnostic test instrument to identify misconceptions in the learning process, and to find out the main source of the causes of misconceptions. The results of the diagnostic test of students who have misconceptions about centripetal and centrifugal forces are 20.31%. The percentage of false positive is 9.62%, the false negative is 8.49 and the Lack of Knowledge is 16.97%. From the percentage results obtained that the false positive (FP) and false negative (FN) values are valid because <10%. The results of the validity test on the instrument are said to be valid because >0.3 and the results of the reliability test are Cronbach's Alpha value obtained at 0.715 from 7 item questions. So this instrument can be said to be reliable because the Cronbach's Alpha value is classified as high based on the reliability criteria.

Kata Kunci: Misconception, Physics, Development, Five-Tier

INTRODUCTION

Physics is a science that studies natural phenomena and all activities in everyday life (Sari et al., 2020). Physics lessons are natural sciences with the scope of science that exists in nature, both concerning living and non-living things, so the laws of physics are also called natural laws (Jati, 2013). Physics is a difficult subject for students to understand, because learning physics uses symbols, the influence of mathematics and intuition to build students' conceptions, this makes students experience wrong understandings, causing misconceptions (Handhika et al., 2015). Many students have difficulty in physics lessons because there are too many formulas and concepts that are difficult to understand (Azizah et al., 2015).

Constraints that are often faced by students where students find it difficult to solve problems in physics lessons, because physics lessons always provide problems that require students to think critically and systematically in solving them (Jiwanto et al., 2012).

Misconception is a student's belief in a concept, where the student's concept is not in accordance with the understanding of the concept by experts, if the number of misconceptions increases then students will have difficulty understanding the concept of the next physics lesson (Akmam et al., 2018). Misconceptions that often occur in physics lessons in almost every topic, where students' prejudice against a concept is one of the problems in physics education, this misconception is an obstacle for further learning (Kizilcik et al., 2015).

Misconceptions can cause a limiting factor for students in studying physics, where the wrong concepts will continue to be carried out by students and it is possible that students will also be hampered in further material related to physics concepts (Maison et al., 2019).

The explanation was also emphasized by Suparno (2013), many misconceptions come from students such as preconceptions, intuition, and student abilities, misconceptions in teachers because teachers do not master physics teaching materials properly, then misconceptions that come from textbooks because of the language in the books. it's hard to understand. The cause of factual misconceptions is the belief in inaccurate information through news, social media, friends, family, classroom learning and interactions in daily activities (Verkade et al., 2016).

A diagnostic test is a test model that is used to find out the learning difficulties experienced by students in a material (Pujiyati et al., 2018). A good diagnostic test can provide an accurate picture and result about the misconceptions experienced by students (Abbas, 2016). Diagnostic tests need to be done because it is to find out the weaknesses and strengths of students in mastering a material, and can identify learning difficulties experienced by students so that they know the failure or success of student learning (Setyono et al., 2016).

The five-tier diagnostic test instrument is a development of the misconception diagnostic test instrument in the form of multiple-tiered choices. The five-tier test is a development of the four-tier test, where there is an addition to the fifth tier in the form of a learning resource questionnaire to find out the causes of the emergence of misconceptions experienced by students (Febriyana et al., 2020). In the five-tier multiple choice test (five-tier test) for the first level contains the content of choice of answers to questions, the second level contains confidence in the answers to questions, the third level contains the reasons for the answers at the first level, the

fourth level contains the level of confidence in the reasons for the answers at the third level, and at the fifth level contains sources from which students answer questions at the first and third levels (Inggit et al., 2021).

The importance of this development research is that it can help in identifying the understanding of concepts in the material of centripetal and centrifugal forces. Can be used as an instrument to assist teachers in identifying students' misconceptions about centripetal and centrifugal forces. Can increase the author's knowledge in developing instruments to identify students' misconceptions in physics lessons about centripetal and centrifugal forces.

Based on the above background, the formulation of the problem in this study is as follows:

1. What is the process of developing a Five-Tier Diagnostic Test instrument to identify students' misconceptions about centripetal and centrifugal forces?
2. How is the Feasibility of the Five-Tier Diagnostic Test Instrument to identify students' misconceptions about centripetal and centrifugal forces?

Based on the formulation of the problem that has been stated, the objectives of this study are as follows:

1. Can find out the process of developing a five-tier diagnostic test instrument to identify students' misconceptions about centripetal and centrifugal forces.
2. Can determine the feasibility of the five-tier diagnostic test instrument to identify students' misconceptions about centripetal and centrifugal forces.

RESEARCH METHOD

Development style

This research is a type of research and development that is often referred to as Research and Development (R&D). Research and Development (R&D) is a research method used to produce a product

and test the effectiveness of the method (Fransisca & Putri, 2019). Research and Development is a research activity that begins with research and then continues with development, where research activities are carried out to obtain information about the needs of researchers, while development activities are carried out to produce a learning device (Prasetyo, 2012). This study uses the R&D method because the results of this study are in the form of a diagnostic test instrument to identify misconceptions in the learning process, and to find out the main source of the causes of misconceptions. From this the teacher can correct the misconceptions that occur in students and find out the main source of misconceptions in students.

The development model used in this study is the 4D (Four-D) development model. According to Amin and Sulistiyono (2021) this development research was carried out using a 4D model adapted from (Thiagarajan & Sammel, 1974), where the 4D model consisted of four stages, namely 1). Define (Defining), 2). Design (Design), 3). Develop (Development), and 4). Disseminate (Spread). This research is limited only to the Develop stage which is in accordance with the research objectives, namely developing a diagnostic test instrument.

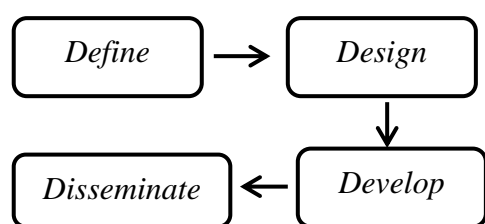


Figure 1. Stages of the 4D Model

Development Procedure

The procedure for developing a five-tier diagnostic test instrument was carried out using a 4D model developed by Thiagarajan et al (1974). This model consists of 4 stages, namely define, design, develop and disseminate.

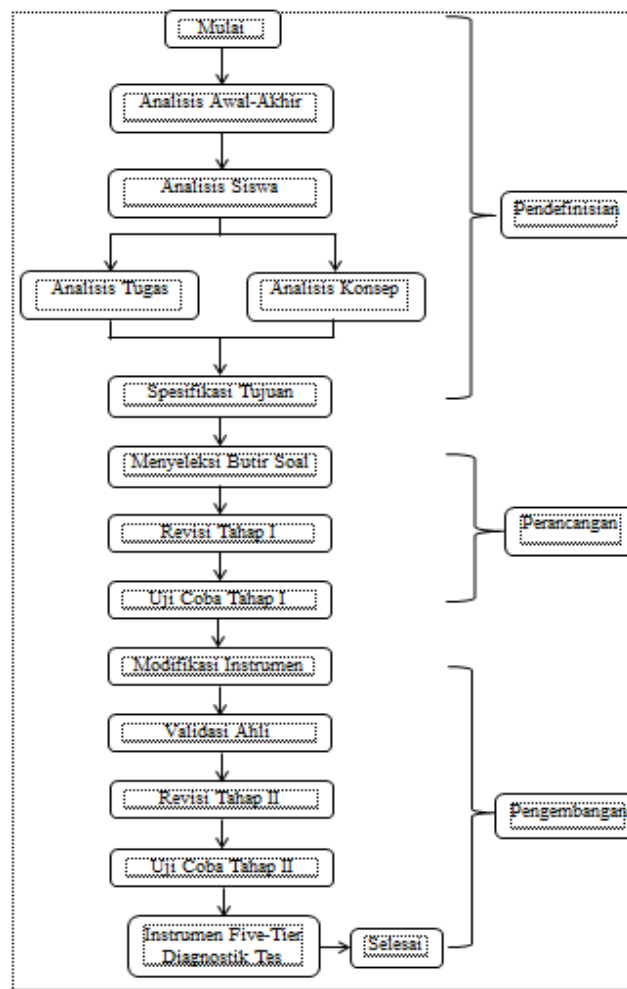


Figure 2. Development Procedure

Subject

The technique of taking the subject in this research is by using purposive sampling. Purposive sampling technique is a technique of determining and taking samples from the research population based on the characteristics and characteristics to achieve research objectives (Maharani & Bernard, 2018). This research was conducted on class XI IPA SMAN 11 Jambi City with 101 students as respondents.

Data Types and Data Sources

In this development research, the types of data used are qualitative and quantitative data. Qualitative data was obtained from a validation sheet in the form of suggestions filled out by a team of experts in improving the five-tier diagnostic test instrument. While quantitative data obtained from the value of the validity and

reliability of the five-tier instrument that has been tested on the subject.

Data source

This study uses primary data sources where researchers take research data directly from the source. According to Pramiyati et al (2017) Primary data sources are data obtained directly from the main source in a study.

Data Collection Instruments

Data collection instruments used in this study are:

1. Test

The test is a question that is used to measure the knowledge of the research subject. The test used in this study is in the form of a multiple-choice test in a five-tier test format on Centripetal and Centrifugal Forces.

2. Expert Validation Sheet

The expert validation sheet is used to determine the validity of the developed diagnostic instrument.

3. Interview

Interviews were conducted to strengthen the data obtained. This interview was conducted with the teacher in the field of physics studies to determine the students' abilities in learning physics.

Data analysis technique

The data analysis technique in this development research is differentiated based on the type of data obtained at the time of the research, namely qualitative and quantitative data.

1. Qualitative Data Analysis Techniques

This research produces qualitative data, namely interviews and instrument validation sheets. The interview was conducted with the teacher in the field of physics studies, where the aim was to obtain information about student learning outcomes. Then on the validation sheet in the form of suggestions and comments given by a team of experts. Qualitative data

were obtained from expert validation questionnaires using a Likert scale.

Tabel 1. Likert Scale Assessment Validation Sheet

Scale	Category
1	Very Bad
2	Bad
3	Good enough
4	Good
5	Excellent

(Sumber: Setyawan dan Atapukan, 2018)

From the percentage obtained, the results are then transformed into qualitative sentences. The percentage range and qualitative criteria are as follows:

Tabel 2. Instrument Validation Percentage Range

Interval	Criterion
81% - 100%	Excellent
61% - 80%	Good
41% - 60%	Good enough
21% - 40%	Bad
0% - 20%	Very Bad

(Sumber : Teresia, 2019)

2. Quantitative Data Analysis Techniques

Validity Analysis

Validity is the most important thing in developing and evaluating a diagnostic test. In addition, validity indicates the level of validity or validity of an instrument. An instrument is said to be valid if the instrument can measure what it wants to measure. A valid instrument has a high validity value, otherwise if the validity value is low then the instrument is less valid or invalid. In the validity analysis there is an analysis of content validity and construct validity. In the content validity analysis, it is done by finding the correct score, misconception score, False Positive (FP), False Negative (FN), Lack of Knowledge (LK), and the main source of student information. The scores for misconceptions are grouped according to the percentage. The following categories of percentage level misconceptions:

Tabel 3. Misconception Rate Percentage Category

Persentase	Category
0% - 30%	Low
>30% - 60%	Medium
>60% - 100%	High

(Sumber: Saheb dalam Maison et al, 2020)

Construct validation states the extent to which the score of the measurement results with the instrument reflects the theoretical construct that underlies the development of the instrument. to determine the validity of the construct is done by calculating the value of the product moment correlation coefficient (r) statistically using SPSS or Excel. In addition, to see the relationship between two variables, it can be seen by using a scatter plot. In addition to calculating the Product Moment correlation coefficient (r), in construct validity, factor analysis is also carried out. Factor analysis is used to test hypotheses regarding the existence of constructs or to search for constructs in variables.

Tabel 4. Validation Interpretation

R Value	Validation Interpretation
0,800 – 1,000	Very High
0,600 – 0,799	High
0,400 – 0,599	Medium
0,200 – 0,399	Low
0,000 – 0,199	Very Low

(Sumber : Hidayat, 2021)

Reliability Analysis

According to Yusrizal (2008), reliability is consistency in measurement or consistency of scores resulting from research. If an instrument is used repeatedly to measure the same thing and the results obtained are relatively stable or consistent. Reliability analysis was carried out using SPSS to determine the value of the Cronbach's Alpha coefficient on the correct score and misconception scores. If a relatively high (r) value is obtained for each data, then the instrument can be said to be reliable.

Tabel 5. Reliability Criteria

r_{11}	Criterion
-1,000 – 0,199	Very Low
0,200 – 0,399	Low
0,400 – 0,599	Medium
0,600 – 0,799	High
0,800 – 1,000	Very High

(Sumber : Lailiyah dan Ermawati, 2020)

RESULT AND DISCUSSION

The type of research carried out is development research by producing a product in the form of a Five-Tier Diagnostic Test instrument. This instrument is structured in several stages, namely Definition, Design and Development. After doing several stages, the Five-Tier Diagnostic Test instrument on Centripetal and Centrifugal Forces was finally obtained with 7 items of questions. The purpose of this study is to identify students' misconceptions about centripetal and centrifugal forces using the developed Five-Tier Diagnostic Test instrument.

In this study using a research and development design, the result of the development of this study is a five-tier diagnostic test instrument that can be used to identify misconceptions that occur in students regarding Centripetal and Centrifugal Forces.

Instrument validation is done by filling out a validation sheet by a team of material and language experts. Furthermore, an assessment of the instrument developed by the researcher was obtained. The expert team's assessment on the validation sheet is as follows:

Tabel 6. Expert Validation Results

Expert	Indicator	(%)	Criterion
1	Instruction aspect	100	Excellent
	Coverage of misconception test instruments	86,66	Excellent
	Accuracy of concepts, principles and laws.	80	Good

Expert	Indicator	(%)	Criterion
	Tata bahasa	85	Excellent
	Average percentage	87,16	Excellent
2	Instruction aspect	80	Good
	Coverage of misconception test instruments	93,33	Excellent
	Accuracy of concepts, principles and laws.	80	Good
	Grammar	85	Excellent
	Average percentage	84,58	Excellent

After the five-tier diagnostic test instrument was declared valid by the validator and revised, the next stage was a trial run to determine the value of validity and reliability. This trial was conducted at SMAN 11 Jambi City, with 101 students as respondents, where the researcher gave the five-tier diagnostic test instrument sheet to the students directly.

Correct Score

The results of the average percentage value of the correct score from this study were obtained the research data as follows:

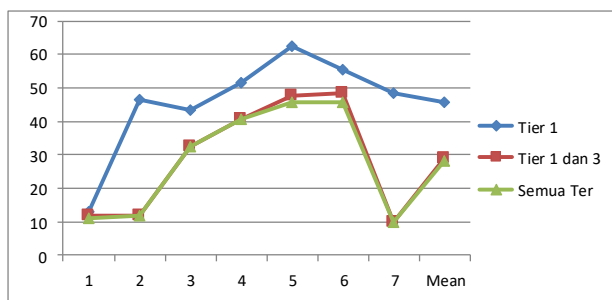


Figure 3. Correct Score Percentage Diagram

Based on the results of the data above, it is known that the percentage of correct scores on tier 1 is greater than the percentage of correct scores on tiers 1 and 3 as well as on all tiers. In tier 1 the percentage of correct scores is 45.83% where the most students answer correctly on item 5 by 62.38% and those who answer correctly on item 1 at least 12.87%. This shows that students who answer correctly

do not necessarily have the right reasons and are sure of the answers given.

Based on Figure 3, it can be seen that the percentage of correct scores on tiers 1 and 3 is 29.00%, where the most students answered the correct score on item 6 of 48.51% and those who answered correctly on item 7 were 9.90%. Meanwhile, when viewed on all tiers, the percentage of correct scores is 28.15% where the most correct scores on items 5 and 6 are 45.54% and the least correct scores on item 7 are 9.90%. If it is seen for correct scores on all tiers, students who get correct scores or understand the material are still relatively low because the correct scores for all tiers are <30%.

Misconception Score

The results of the average percentage score of misconceptions from this study are obtained the research data as follows:

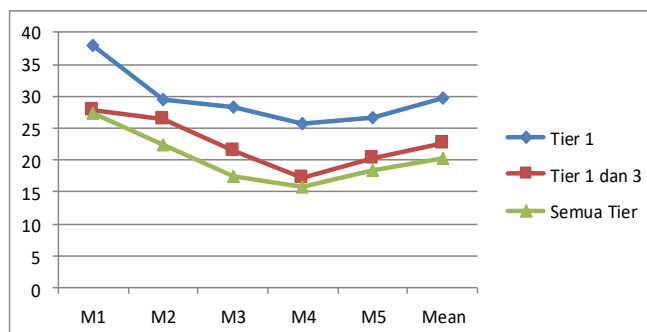


Figure 4. Misconception Score Percentage Diagram

Based on Figure 4, it can be seen that the percentage of misconception scores on tier 1 is greater than the percentage of misconception scores on tiers 1 and 3 as well as on all tiers. In tier 1 the percentage of true misconceptions is 29.61% where students experience the most misconceptions according to the misconception answer key in item 1 of 37.91% and the least on item 4 is 25.74%. Many students experience misconceptions in the answers to questions that allow students not to understand the material well.

Based on Figure 4, it can be seen that the percentage of misconception scores in tiers 1 and 3 is 22.70%, where students experience the most misconceptions on

item 1 of 27.86% and the least on item 4 of 17.33%. Meanwhile, when viewed on all tiers, the percentage of misconception scores is 20.31% where the highest misconception score is in item 1 of 27.30% and the least score is on item 4 which is 15.84%. Judging from the misconception scores on all tiers, students who experience misconceptions are classified as low because <30%.

Main Source of Student Information

Based on the results of the Phase II trial with the five-tier diagnostic test instrument at tier 5, namely to see the main sources of information for students in answering questions and the reasons for the answers, it can be seen from table 7 below:

Table 7. Results of Students' Main Information Sources

Resources	Mean
Book	5,37%
Internet	16,97%
Teacher's Explanation	3,39%
Observation Result	4,52%
Personal Thought	54,31%
Friend	15,42%

Based on the table above, it can be seen that the main source of information given by students in answering questions and reasons mostly comes from students' personal thoughts, which is 54.31% and the least is the teacher's explanation, which is 3.39%.

1. Validity Analysis

To determine the validity of an instrument developed, it can be seen from the content validity and construct validity. Following are the results of the analysis of the validity of the five-tier diagnostic test instrument.

Content validity is done quantitatively by looking at the percentage results of False Positive (FP), False Negative (FN) and Lack of Knowledge (LK). If the student answers correctly on the question and is

sure, then answers incorrectly on the reason and is sure then it is included in the False Positive (FP) category. (FN). Furthermore, if students answer right or wrong on the question, right or wrong on the reason and are not sure of the answer or reason, then the answer pattern is included in the category of Lack of Knowledge (LK). For FP, FN and LK data, see (attachment 8). The value of content validity can be said to be fulfilled or valid if the value is False Positive and False Negative < 10%. The following is the percentage result for FP, FN and LK data:

Table 8. Percentage Results of FP, FN and LK

Kategori	Persentase (%)
False Positif (FP)	9,62
False Negatif (FN)	8,49
Lack of Knowledge (LK)	16,97

Based on the results of the percentage data in Table 4.6, it can be seen that the value of false positive is 9.62%, false negative is 8.49 and Lack of Knowledge is 16.97%. Then the value for content validity is fulfilled or valid because the data that has been obtained shows that the false positive (FP) and false negative (FN) values are <10%.

This construct validity was carried out using SPSS software. Where the purpose of this construct validity is to see the relationship between variables using a scatter plot as follows:

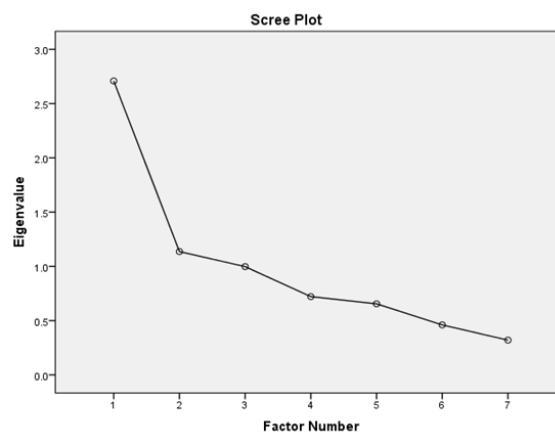


Figure 5. Scree Plot Test Results

Based on the scree plot image above, it can be seen that there are 2 points that have an Eigenvalue >1 . So it can be said that there are 2 factors formed. Then to find out the grouping of items into 2 component factors that are formed can be seen with the Rotated Factor Matrix Table. The construct validity in Table 9 is as follows:

Table 9. Construct Validity Results

Rotated Factor Matrix		
	<i>Factor</i>	
	1	2
<i>Item_1</i>	.327	
<i>Item_2</i>		.401
<i>Item_3</i>	.365	.539
<i>Item_4</i>	.490	.665
<i>Item_5</i>		.575
<i>Item_6</i>	.993	
<i>Item_7</i>	.343	

Based on the results of construct validity in Table 9 above, it can be seen that there are several items that have more than one factor such as item 3 and item 4 which have a high loading factor, namely > 0.3 on 2 factors, which means that the item can measure 2 factors at once. Meanwhile, item 1, item 2, item 5, item 6 and item 7 have a high loading factor, namely > 0.3 on 1 factor, which means that the item can only measure 1 factor. The items contained in factor 1 are item 1, item 3, item 4, item 6 and item 7. And the items contained in factor 2 are item 2, item 3, item 4 and item 5.

2. Reliability

The reliability test was carried out by using SPSS Software to see the Cronbach's Alpha value, while the reliability results from the data that had been obtained were as follows:

Table 10. Reliability Test Results

Reliability Statistics	
Cronbach's Alpha	N of Items
.715	7

Based on the results of the reliability test in Table 10 above, it can be seen that the Cronbach's Alpha value is 0.715. So this instrument can be said to be reliable because the Cronbach's Alpha value is classified as high based on the reliability criteria. This instrument is also said to be reliable because it contains consistent item items.

CONCLUSION

This study produced a product in the form of a five-tier diagnostic test instrument that was used to identify high school students' misconceptions about centripetal and centrifugal forces with a total of 7 items. This instrument has been validated by 2 experts. This instrument is declared very good with a percentage of 84.58% by the validation team and the instrument can be used to test the Misconception diagnostic test on students. The results of the diagnostic test of misconceptions that occur in students get the percentage at the first level of 29.61%, at the first and third levels of 22.70% and at all levels (1-4) of 20.31%. The results of identifying sources of information for students in answering questions and reasons obtained the largest percentage results, namely personal thoughts of 54.31%. In the validity test using the SPSS program and the results obtained that all item items are declared valid because > 0.3 . The results of the instrument reliability test using the SPSS program by finding the Cronbach's Alpha value obtained are 0.715 out of 7 item questions. So this instrument can be said to be reliable because the Cronbach's Alpha value is classified as high based on the reliability criteria. This instrument is also said to be reliable because it contains consistent item items.

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