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Four-tier Diagnostic Test to Assess Students' Misconceptions about Fluids: A Story from Development to Measurement from Three Environmental Sites

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Abstract: This study aims to develop a Four-Tier Fluid Material Misconception Diagnostic Test instrument that can provide an overview of the misconception profile of high school students in Southeast Sulawesi. This study uses the Research and Development (R&D) method with XI grade high school students in three districts/cities in Southeast Sulawesi. The stages of the research adapting the Brog and Gall method are preliminary studies; product planning and design; and product testing. Data analysis techniques on content validity testing using V' Aiken; empirical validity testing using the Rasch approach with WINSTEP 3.73 software, the profile of misconceptions at the limited trial stage and broad trials using the categorization of the Diagnostic Four-Tier Test. From the results of the content validity test and empirical validity, it is shown that the diagnostic test instrument for the Four-Tier Misconception Test for Fluid Materials is in the valid and reliable category (r = 0.87 = 0.05). This research has succeeded in developing a diagnostic test instrument for the Misconception Four-Tier Test for Fluid Materials as many as 20 items which can describe the misconception profile of class XI high school students with good criteria. The highest misconception is in the Archimedes Law Sub-concept of 36.30%. Students' misconceptions on fluid material from research subjects were obtained by Kendari City by 29.50%; East Kolaka Regency by 35.70%; and Kabupaten Bombana by 32.20%.

Keywords: Four-tier test; Misconception; Fluid

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Introduction

Physics is a branch of natural science that studies the phenomena of matter, energy, and their interactions (Ramadhan et al., 2019). Given the importance of the role of Physics for mankind, the learning process of Physics in schools must take place properly, in this case the understanding and application of Physics concepts to students must be appropriate. Physics subjects need to be taught for a more specific purpose, namely to provide students with the knowledge, understanding, and a number of abilities required to enter higher education levels and develop science and technology.

Physics is part of science that emphasizes mastery of concepts (Zamista & Kaniawati, 2015). Physics concepts are often difficult to understand correctly and completely by students, causing misinterpretations. This makes students think that Physics is a difficult material, because it contains concepts that are difficult to understand. Conceptions that arise in students are essentially caused by factors including: intuition of everyday life, the learning process, reading textbooks, students' knowledge as fragments, specific theoretical frameworks and conceptual appreciation (Linuwih, 2011).

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Prior to obtaining knowledge from the teacher, some students have obtained initial knowledge that is obtained indirectly through non-formal teaching such as experiences in everyday life (Tuysuz, 2009). Sometimes students misunderstand the initial knowledge so that when learning in class students have difficulty understanding the new knowledge provided by the teacher (Treagust, 2007). This is because students build new knowledge using their initial knowledge (Libarkin and Kurdziel, 2001). The difference between the concept of science in general and the concept in the minds of students is what is called a misconception (Eryilmaz, 2010). Winarni & Syahrial, (2016) argue that misconceptions are understandings that are not in accordance with the understanding accepted by scientific experts. This shows that misconceptions hinder students in understanding scientific concepts.

The first step to identify and find out the problem of misconceptions in students is a preliminary study and literature study. The researcher conducted a preliminary study on three Physics teachers of class XI MIPA who suggested that one of the physics materials that often experienced misconceptions was fluid. Fluid is one of the materials in physics which includes two concepts, namely static fluid and dynamic fluid. In addition, fluid is also a material whose applications and symptoms are close to everyday life. Misconceptions include: 1) inaccurate understanding of the fluid concept, 2) incorrect application of the fluid concept, and 3) inappropriate use of mathematical equations.

From the results of these observations, it can be concluded that the teacher is not aware of and does not know that there are misconceptions in students that cause low student learning outcomes. The teacher has also never done a test to identify and find out the students' misconceptions about fluid material. In addition, teachers usually give a concept comprehension test only with practice questions or daily tests, the results of which are still unsatisfactory because there are still many students who experience remedial. Therefore, teachers need an efficient way to find out these misconceptions. There are many ways that can be used to identify misconceptions that occur in students, namely by interviews, questionnaires, open and close questions and multiple choice tests (Wijaya et al., 2016). One of the right steps to detect misconceptions is by using a special instrument, namely a diagnostic test.

The diagnostic test instrument developed is a four-tier test diagnostic test. The advantages of the four-tier diagnostic test are that the teacher can: 1) distinguish the level of confidence in the answers and the level of confidence in the reasons chosen by the students so that they can dig deeper into the strength of students' conceptual understanding; 2) diagnose misconceptions experienced by students more deeply; 3) determine the parts of the material that require more emphasis; 4) planning better learning to help reduce students' misconceptions (Amin, 2016).

The test instrument can be said to be of good quality if it meets the valid, effective, and practical criteria (Nieveen, 1999). There are two validitys determined, namely content validity and empirical validity. Content validity is a measure of the suitability of the entire instrument compiled with parts of the instrument based on the results of reasoning. Empirical validity is the validity that is determined from the data generated by an instrument based on the results given by students from the try out stage to determine the characteristics of the items. Effectiveness is the level of success of an instrument to achieve predetermined goals or the entire cycle of input, process and output which refers to the results of the instrument stating the extent to which the objectives have been achieved. The most important aspect of effectiveness is knowing the level or degree of product application (Rochmad, 2012). While the practicality of an instrument is defined as a measure of the ease of preparing, using, interpreting, and obtaining results (Yusliani, 2019).

Based on this description, this research aims to:aims to develop a Four-Tier Fluid Material Misconception Diagnostic Test instrument that can provide a description of the misconception profile of high school students in Southeast Sulawesi

Method

Research Type and Design

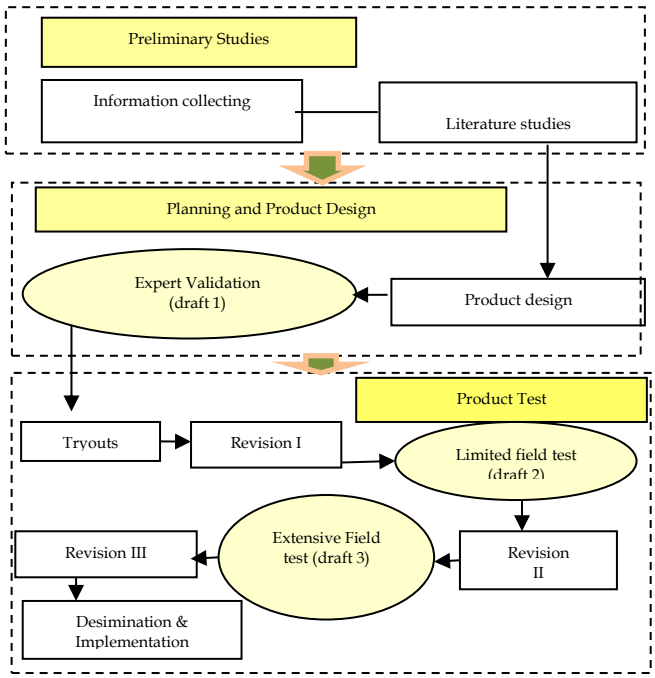

Figure 1. Stages of Research and Development of a Diagnostic test Misconception Four-Tier Test for Fluid Materials

This type of research is Research and Development (R&D) research, which aims to:to develop a product in the form of a Four-Tier Fluid Material Misconception Diagnostic Test instrument that can provide an overview of the misconception profile of high school students in Southeast Sulawesi.The product was developed using adaptations of the Brog and Gall development model, which includesthree main stages, namely (1) preliminary study; (2) product planning and design; (3) product testing, as shown in Figure 1.

The instrument development steps adapted from the Brog and Gall development model (2003) are summarized into three main stages, namely (1) preliminary studies, (2) product planning and design and (3) product testing.

Preliminary studies in the form of: a) the results of interviews with Physics teachers related to learning difficulties experienced by students in fluid materials; b) literature related to students' misconceptions on fluid material. The planning and product design stages are divided into two, namely the product draft design and content validation (draft 1). Meanwhile, the product testing stage consists of a tryout stage, stage I revision, limited trial (draft 2), stage II revision, large-scale trial (draft 3), stage III revision, dissemination and implementation.

Table 1. Content Validation Review Criteria (draft 1)

Aspect	Criteria for review
Theory	1. Suitability of test objectives
	2. Compatibility of competencies and indicators
	3. Appropriateness of aspects of concept understanding
Construct	1. Availability of instructions for doing questions
	2. The question does not cause double interpretation
	3. Clarity of question formulation
	4. Clarity of answer options
	5. Measuring students' conceptual understanding
	6. Measuring the categorization of concept understanding
Language	1. Use language according to good and correct Indonesian rules
	2. Easy to understand and adaptive

(Adapted from the Ministry of National Education, 2008)

Data Analysis Stages

The validity of the content validity of the four-tier test diagnostic misconceptions was analyzed using the V'Aiken Formula 1.

$$V = \frac{\sum n_i |i - I_o|}{[N(c-1)]} \quad (1)$$

with: V = item validity index; i = the number given by the rater; I_o = lowest scale; c = highest scale; ni = number of values in i; and N = $\sum n_i$.

Table 2. Content Validity Criteria

Aiken Index (V)	Interpretation
0.81 – 1.00	Very valid
0.61 – 0.80	Valid
0.41 – 0.60	Quite valid
0.21 – 0.40	Not valid
0.00 – 0.20	Invalid

(Landis, JR 1977)

Empirical validity which consists of item validity, reliability, level of difficulty and discriminating power of the questions were analyzed through the approach Rasch with WINSTEP 3.73 software.

Table 3. Criteria for Empirical Validity Components

Components of Empirical Validity	Criteria	Interpretation
Item validity, criteria:		
MNSQ (0.51 - 1.49)	Minimum 2 Criteria.	Valid
ZSTD (-1.99 – 1.99)	1 Criteria.	Revision
Pt Measure Corr (0.41 – 0.84)	Nothing fulfills	Invalid
Reliability	Alpha Cronbach> 0.60	Reliable
	Alpha Cronbach> 0.60	Unreliable
Difficulty level	< -1	Very easy
	-1 – 0	Easy
	0 – 1	Difficult
	> 1	Very easy
Distinguishing power	0.40 < ID	Very good
	0.30 ID 0.40	Well
	0.20 ID < 0.30	Not good
	ID < 0.20	Bad

(Sumintono & Widhiarso, 2015)

The profile of the Four-Tier Test Misconception Diagnostic Test category can be seen in Table 4.

Table 4. Combination of Four-Tier Test. Diagnostic Test Answers

Category	Tier 1	Tier 2	Tier 3	Tier 4
Understand the concept	Right	Certain	Right	Certain
Misconception	Wrong	Certain	Wrong	Certain
Don't understand	Right	Not sure	Wrong	Certain
the concept	Wrong	Not sure	Wrong	Certain
	Right	Certain	Right	Not sure

Category	Tier 1	Tier 2	Tier 3	Tier 4
	Right	Certain	Wrong	Not sure
	Right	Not sure	Right	Certain
	Right	Not sure	Right	Not sure
	Right	Not sure	Wrong	Not sure
	Wrong	Certain	Right	Not sure
	Wrong	Certain	Wrong	Not sure
	Wrong	Not sure	Right	Not sure
	Wrong	Not sure	Wrong	Not sure
	Right	Certain	Wrong	Certain
	Wrong	Certain	Right	Certain
	Wrong	Not sure	Right	Certain

(Gurel et al., 2015)

Results and Discussion

Preliminary stage

The results of interviews with Physics teachers at SMAN 2 Kendari, SMAN 10 Kendari, and SMAN 5 Kendari in Kendari City found that students had difficulties in applying mathematical equations to fluid concepts which caused errors in understanding fluid concepts. This is presumably due to a misconception in the material.

The misconceptions that occur in fluid matter empirically can be seen in Table 5.

Table 5. Empirical Study of Fluid Material Misconceptions

Sub concept	Empirical Study of Misconceptions
Hydrostatic Pressure	Hydrostatic pressure depends on the volume of water in the container and the shape of the container (Ahmad, et al. 2016)
Floating Style	Misconceptions on buoyancy are caused by students not understanding the concept of forces acting on buoyancy (Seyit et al, 2015) When a stone is placed in a glass that contains liquid, students will say the stone does not float even though this is wrong (Manoj, 2014).

Product design

From the results of interviews and literature review, it is determined that the preparation of questionsDiagnostic Tests Four-Tier Misconception Test onfluid material. Development begins with the preparation of a grid of questions by paying attention to Basic Competencies and Indicators. 25 questionsDiagnostic Tests Four-Tier Misconception Test onfluid materials are arranged in an alternative answer presentation format (tier 1); the level of confidence in the answers (tier 2); reasons for choosing the answer (tier 3); and the level of confidence in the reason for choosing the answer (tier 4).

Product Validation (Draft 1)

Diagnostic test the four-tier misconception test is carried out with content validation and empirical validation. The results of the revision, responses and suggestions of the validator become the material for draft 2.Based on the results of content validity and empirical validity of the four-tier misconception diagnostic test for fluid materials, 20 items were declared valid, 5 items were declared invalid. The test that has been developed serves to describe the misconception profile of class XI high school students in Southeast Sulawesi.

The presentation of data on the results of content validity and empirical validity can be seen in Table 6.

Table 6. Validation Results of the Four-Tier Misconception Diagnostic Test for Fluid Materials

Content Validity					
Aspect	Average Score			V'Aiken	Criteria
	Expert 1	Expert 2	Expert 3		
Theory					
Suitability of test objectives	3.9	3.9	3	1.0	Very valid
Compatibility of competencies and indicators	3.4	3.4	4	1.0	Very valid
Appropriateness of aspects of concept understanding	3.2	3.2	4	0.9	Very valid
Construct					
Availability of instructions for doing questions	3.8	3.8	4	1.00	Very Valid
The question does not cause double interpretation	3.8	3.4	4	1.0	Very Valid
Clarity of question formulation	3.5	3.4	4	1.0	Very Valid
Clarity of answer options	3.2	3.5	4	0.9	Very Valid
Measuring students' conceptual understanding	3.4	3.4	4	1.0	Very Valid
Measuring the categorization of concept understanding	3.1	3.4	4	0.9	Very Valid
Language					
use language according to good and correct Indonesian rules	4	4	4	1.0	Very Valid
Easy to understand and adaptive	4	4	4	1.0	Very Valid
					Empirical Validity

Item validity	MNSQ (0.58 – 2.34) ZSTD (-0.1 – 4.1) Pt Measure Corr (0.30 – 0.65)
Reliability	0.87
Distinguishing Power	0.30 – 0.65
Difficulty level	(-0.11 – 0.67)

Product Testing Stage

The trial (draft 2) was conducted on 39 students of class XI of SMAN 6 Kendari and 16 students of SMAN 7 Kendari. Trial goalThis limit is to determine the level of readabilityDiagnostic test The misconception of the four-tier test on fluid materials.The results of the limited trial analysis as shown in Figure 2 found misconceptions related to students' hydrostatic pressure in terms of; 1) students have a misunderstanding in determining the liquid level in the U-pipe in the case of hydrostatic pressure; 2) students believe that the hydrostatic pressure is greater in a narrow place.

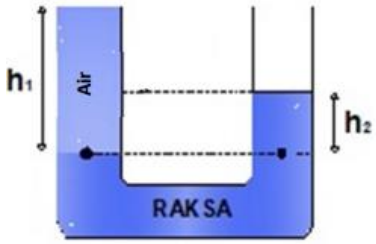

Figure 2. Hydrostatic pressure in two liquids with different densities

The trial (draft 3) was carried out on students of class XIHigh School in Kendari Cityas many as 83 students, East Kolaka Regency as many as 76 students, and Bombana Regency as many as 51 students. The misconception profiles of class XI SMA students from three districts/cities can be seen in Table 7.

Table 7. DataProfile of Understanding the Concept of Fluid Materials for Class XI High School students

County/City	Number of Respondents	Percentage of Students (%)		
		Understand Concept	Misconception	Don't Understand Concept
Kendari	83	25.6	29.5	44.9
East Kolaka	76	14.9	35.7	49.4
Bombana	51	19.3	32.3	48.4

The results of the Four-Tier Misconception Test Diagnostic Test for fluid materials can be seen in Figure 3.

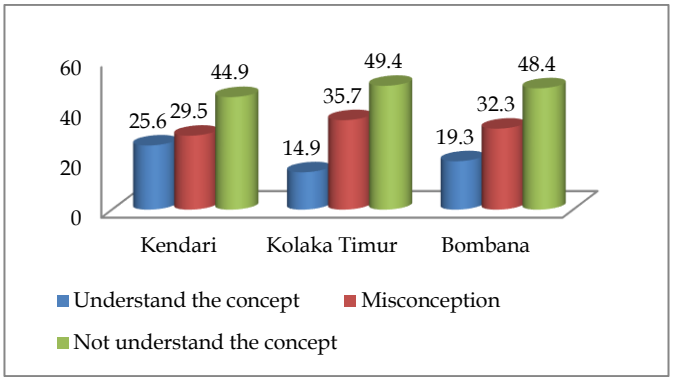

Figure 3. Profile of Understanding Fluid Material Concepts for Class XI SMA students from three regencies/cities

Misconceptions can be in the form of initial concepts, errors, incorrect relationships between concepts, intuitive ideas or naive views. Misconception as an interpretation of concepts in an unacceptable statement. Misconceptions as inaccurate understanding of concepts, use of wrong concepts, wrong classification of examples, confusion of different concepts, and incorrect hierarchical relationships of concepts.This is supported by the opinion of Lin et al (2004) which states that students only gain conceptual knowledge through memorizing without understanding the concept so that they tend to act without rethinking and not coming up with their own ideas.

The highest misconception occurs in the sub-concept of Archimedes' law. Students assume that the greater the volume of an object, the object tends to sink. The factor causing this misconception is that students do not understand the concept of density of substances and incomplete/wrong reasoning. Students spontaneously express their ideas without researching or thinking rationally. This is in line with research conducted by Zukhruf, (2018) that the highest misconception is in Archimedes' law material. Students do not understand that the state of an object is not affected by the size of the object but is influenced by the density, mass, and volume of the substance.

Conclusion

The test instrument for the Diagnostic Misconception Four-Tier Test has been developed as many as 20 items that are valid, effective, practical, and reliable. From the results of empirical testing, it was found that the highest level of misconception is in the sub-concepts of Archimedes' law and hydrostatic pressure. Based on the results of research dsuggest to develop test diagnostic misconceptions four-tier fluid material test with a larger number of questions to make it more representative. It is hoped that developing solutions to suppress misconceptions in the sub-concepts of Archimedes' Law and Hydrostatic Pressure.

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