Development of diagnostic test instruments to reveal

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Abstract. The purpose of this research was to develop a diagnostic test instrument to reveal students' conceptions in kinematics and dynamics. The diagnostic test was developed based on the content indicator the concept of (1) displacement and distance, (2) instantaneous and average velocity, (3) zero and constant acceleration, (4) gravitational acceleration (5) Newton's first Law, (6) and Newton's third Law. The diagnostic test development model includes: Diagnostic test requirement analysis, formulating test-making objectives, developing tests, checking the validity of the content and the performance of reliability, and application of tests. The Content Validation Index (CVI) results in the category are highly relevant, with a value of 0.85. Three questions get negative Content Validation Ratio CVR) (-0.6), after revised distractors and clarify visual presentation; the CVR become 1 (highly relevant). This test was applied, obtained 16 valid test items, with Cronbach Alpha value of 0.80. It can conclude that diagnostic test can be used to reveal the level of students' conception in kinematics and dynamics.

1. Introduction

The diagnostic test have a clinical connotation as a diagnosis, borrowed from the pharmaceutical term, which shows the process of determining the nature and state of the illness [1]. In the context of learning, diagnostic tests are used to identify the causes of student learning difficulties [1]. Furthermore, diagnostic tests are deeper than formative tests, not only describing how students learn but explaining the causes of learning difficulties that arise. The diagnostic test results are often not reported to the student but used by the lecturer to measure where to begin the lesson [2]. Diagnostic tests are used to help identify weaknesses and for treatment [3].The problem in question can a particular subject matter or skill [4]. The conception diagnostic test is used to reveal conceptions of the students.

Many diagnostic test models have been developed to reveal student conceptions; open-ended questions (OPQ), interviews (I), and (D) drawing, and, multiple choice (MC). All of the models, of course, has advantages and disadvantages and developed base on the needs and objectives. OPQ model able to reveal the conception of the students in depth, there is no pressure [5–7]. The advantages of OPQ model besides giving students freedom in giving responses as well as questions systematically arranged can identify the specific conceptions of the students. The weakness of the OPQ model is that students' answers can be diverse so that conception assessment indicators cannot cover all respond [5–7]. Consequently, the student answers need to be re-evaluated by the lecturer. The model I has the advantage of identifying student conceptions more deeply, and the conception

information obtained is more accurate than the other instruments. Interviews provide an opportunity for lecturers to uncover students' conceptions to their causes. The weakness of OPQ and I is that it takes a long time if applied to a large population, this model becomes ineffective.

The drawing model is an evaluation model used for specific purposes and materials [8–10]. In physics, concepts can present in visual, verbal, and mathematical forms [11,12]. The concept presented in the form of visual and mathematical (graphics) can use drawing model. The drawing model had difficulty in correction, categorization, interpretation and limited to certain concepts.

MC is a widely used model. Consideration of using MC is effectiveness in time and evaluation process [13–15]. MC is more efficient, practices, but cannot identify in-depth the student's conception [15].The development of diagnostic test MC-based continues to be developed by researchers, from simple multiple choices to complex multiple choices test (three tiers). The development of test is continuously carried out to obtain the appropriate instruments with the goals and needs. In this research has developed the diagnostic test that can reveal the conception of the students.

2. Methods

Instruments developed following this step (1) test requirement analysis, (2) formulating test-making objectives, (3) developing tests, (4) checking the validity of the content and the performance of reliability. In the development stage, a level of certainty and a short argument is added to the test to reduce the weakness of the MC. In addition to developing test instruments, conception indicators also developed. Indicator conception as follows: misconception about (1) displacement and distance, (2) instantaneous and average velocity, (3) zero acceleration, constant acceleration, and velocity, (4) gravitational acceleration, (5) Newton's first law, (6) Newton's third law. The test validated by five experts and analyzed the CVR and CVI values [16–17]. After the tests were declared valid by the experts, the test applied to 50 students who had taken basic physics to obtain reliability information. Tests were developed to reveal the level of conception, which presented minimally in two presentations, verbal, mathematical, or visual.

3. Result and Discussion

3.1Test Requirement Analysis.

The test requirement analysis is done with the following steps. The first step in the development of a diagnostic test is (a) reviewing the literature on the form of diagnostic tests, (b) profiling students' misconceptions, (c) formulating the instrument development objectives.

3.1.1. Results of the Literature Review

Based on the results of the literature review, selected MC with consideration of time efficiency. Potential weaknesses and benefits of MC diagnostic tests are analyzed and described. The two-tiers MC has benefits including 1) relatively comfortable for the student in responding, 2) more practical and efficient for the lecturer and reducing the assumption of guessing answers to multiple-choice questions, 3) enabling for large-scale assessment. The weakness of the two-tiers is a student indirectly assisted in choosing answers and description of a brief argumentation [18-20]. The weakness in the form of a two-tier test is the basis for developing a conception diagnostic test instrument.

3.1.2. Profiling students' misconceptions

The student's conception profile was based on previous research recommendations [21,22]. Findings of misconceptions of students are profiled and used to produce diagnostic test indicators (Table 1).

Table 1. Indicator of diagnostic tests

Subject content	Indicator of conception content	Sub Content Indicators (Student misconceptions)	Test Number
Kinematics	Displacement and distance.	Equalize the concept of displacement and distance	1 2
	Instantaneous and average velocity.	Equalize the concept of instantaneous and average velocity	3 4
	Zero and constant acceleration.	Equalize the value of zero and constant acceleration	5 6
	Gravitational acceleration.	If an object moves closer to the earth, then the acceleration of gravity will increase.	7 8
		In the parabolic motion, the weight of an object influences its distance.	9 10
Dynamics	Newton's first Law.	At the object in a state of stopping, then there are no forces acting on it.	11 12
		The law of inertia is limited only to the occurrence of automobile braking and does not review the observer frame..	13 14
	Newton's third Law.	Equalize Newton's first and third laws	15 16

3.1.3. Formulating test-making objectives

Based on the findings (Table 1) and literature review, the objective of developing the instrument is to reveal the conceptions of the students.

3.2. Developing tests

The various weaknesses of the MC tests were assessed for their weaknesses and found alternative solutions. Selected Force Concept Inventory FCI diagnostic tests developed by [13]. The FCI test analyzed its relevance, presentation, and proportion.

3.2.1. Relevance Analysis

The relevance analysis considered by comparing the conception findings (Table 2) with the FCI test. If there is an FCI problem in accordance with the conception findings, then the item should be considered as one of the test items. Table 2 presents relevance analysis of the test.

Table 2. Examples of Relevance Analysis

Student misconceptions	FCI Test Number 17	Result
If an object moves close to the earth, then the acceleration of gravity will increase.	A stone falling from the roof of a single story building to the surface of the earth; (A) reaches its maximum speed quite soon after release and then falls at a constant speed thereafter. (B) speeds up as it falls, primarily because the closer the stone gets to the earth, the stronger the gravitational attraction. (C) speeds up because of the constant gravitational force acting on it. (D) falls because of the intrinsic tendency of all objects to fall toward the earth. (E) falls because of a combination of the force of gravity and the air pressure pushing it downward.	Problem FCI Number 3 is relevant to conception findings. This item should be considered to be one of item test that will develop.

Relevance analysis by making FCI questions in the OPQ form. Open-ended is used to adjust the choice of answers with the conception of students in Indonesia. An example of the results of the relevance of the answer choices (Table 3). In addition to Open-ended, interviews are also used to explore students' understanding. An example of an analysis of the relevance of the choice of the answer (presentation) (Table 3), makes it clear that the FCI question is relevant to the conception of students in Indonesia. Open-ended FCI Questions are given to 9 students who have basic physics grades in the high category, clarification in the form of interviews also conducted to explore student conception.

Table 3. Examples of Relevance Analysis of the answer options

FCI Test	Students Conception	Analysis
A stone falls from the top of a building on the surface of the earth. Describes the condition of the stone speed and give brief arguments!	Profile of student conception * (Editors have changed without changing the content) (1) The stone speed Increases (fast) because there is a force of gravity (3 students) (2) The stone speed Increases (fast) because there is gravity (4 students (3) The stone speed The faster, closer to earth, the acceleration of gravity is greater, so the object becomes faster (2 students)	In answer number 1,2 need to be studied about the concept of gravity acceleration and force. The interview result shows that two students are still confused to distinguish acceleration of gravity and gravity force. From the interview, information obtained that the students have conceptions the "gravity" is the acceleration of gravity and can also attribute to the force of gravity. Conception number 3 appears intuition because the student analogy plays a role.

Based on Table 3 it can be concluded that the presentation of choice answers presented on the question of the selected FCI test, is still relevant to the answers submitted by the students. The Choice answers test relevant if more than 50% of the presentation answers represent student conceptions.

3.2.2. Presentation and Proportion Analysis

Presentation of test questions is a recommendation of previous research results [11,12,23]. FCI No. 3 is an example of a verbal presentation. It is necessary to present the questions with different presentations and related to the conception findings (Table 4).

Table 4, is an example of a presentation analysis of visual form, with a presentation of verbal choices (Figure 2). The diagnosis of conception test developed by adding the index of certainty (Table 5) adopting from [24].

Table 4. Example of Presentation Analysis

Students Conception	test
If an object moves closer to the earth, then the acceleration of gravity will increase.	 **Figure 1**. two iron balls dropped from different heights The statement corresponding to Figure 1, A. The gravity acceleration of the green ball is greater than the yellow ball B. The gravity acceleration of the green ball twice of a yellow ball C. The gravity acceleration of the green ball is greater than yellow, but not up to twice. D. The speed of yellow ball is greater than the green ball E. The gravity acceleration of yellow ball, similar to the green ball.

Table 5. Category of Student Conception Level with index of certainty

index of certainty low ($K \leq 2$)	index of certainty medium $2 < K < 5$	index of certainty high $K \geq 5$
The answer is correct, low level of certainty, students guess the answer. **Level 1a**	The answer is correct, medium level of certainty, students have a chance to guess answers or have little knowledge of the concept. **(Level 2a)**	The answer is correct, high level of certainty, students understand the concept **(Level 3)**
Incorrect answer, low level of certainty, Students have no knowledge of the concepts. **Level 1b**	Incorrect answer, medium level of certainty, students are likely to guess the answers or have little knowledge about the concept. **(Level 2b)**	Incorrect answer, low level of high, students experience a misconception. **(Level 2c)**

Test work instructions.
Time Allocation: 60 Minutes
A. Choose the correct answer by writing a, b, c, d, e on the answer sheet provided!
B. Select the level of certainty of your answer by crossing (x) in the range of 1 to 7! Choice, the level of certainty as follows:
1 = overall guess answers
2 = most guess answers
3 = uncertain
4 = a definite small part
5 = some are certain
6 = almost certainly
7 = sure
16. In an object, forces applied in opposite direction (Fig. 4.). If both forces are released, applicable:
(1) Newton's first law
(2) Newton's second law
(3) Newton's Third Law, because there is an action-reaction between $\vec{F}_1$ and $\vec{F}_2$
The corresponding statements are:
a. 1 b. 1 & 2 c. 1 & 3 d. 3 e. Not applicable Newton's laws
The level of certainty
1 2 3 4 5 6 7
brief argument.
.....
.....

Figure 2. The Sample of Instrument test

3.3. Checking the validity of the content and the performance of reliability and application of tests.
Multiple-choice tests, completed with the level of certainty, and brief arguments validated their contents to five experts and tested to 50 students who have taken basic physics. The results obtained CVI = 0.85, with test number 1 get negative CVR (-0.6), after revised distractor and visual presentation, CVI value becomes 1 (very relevant). This test was applied, obtained 16 valid test items, with Cronbach Alpha value = 0.80.

4. Conclusions

This research has developed MC using a visual and text presentation questions with equipped the level of certainty and brief argumentation. The MC test with the level of certainty provides information about the level of conception that the students have, the argumentation provides the strengthening of the conception that the students have qualitatively. there were 16 items of diagnostic tests to reveal student conceptions about the concept of kinematics and dynamics. This test based on six indicator and nine sub-indicator components obtained from previous studies. Based on the validation results by the validator, it concluded that the instrument could use, but some of the tests need to fixed in part of the visual presentation. The diagnostic test was tested on 50 students, obtained that it is highly relevant and reliable to reveal students' conceptions.

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