Development of e-learning-based three-tier diagnostics test on the basic physics course

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Abstract. This research about development of three tier diagnostic tests Based on e-learning to identify student misconceptions of student in physics education department Universitas Syiah Kuala. This research uses ADDIE model and random sampling techniques. The sample in this study was physics education students in odd semester 2018/2019 consisting of first semester students in class A, B, and C with 56 students. The instrument used in the form of test validation. The data obtained were analyzed using validity, reliability, difference power, difficulty level, normality test, homogeneity and t-test. The results showed that the misconceptions of class A and C students were remediated compared to class B. This indicates that e-learning based three-tier diagnostic tests are effectively used to identify student misconceptions.

1. Introduction
The pre-service teachers have high competencies on the knowledge that gained from the computer and ICT-based course, such as internet usage, word processing and presentation software, and the use of some types of hardware[1]. Computer-based assessments are new in response to the challenge of assessing large numbers of students [2]. The advantages of computer-based testing are security testing, reducing costs and time, fast results to be obtained, automatic recording for test distribution analysts, data collection without paper use, efficient, fast feedback; tend to have a positive effect on students’ motivation, concentration and performance, and able to provide detailed reports for teachers and students regarding strengths and weaknesses that can support formative assessment.

One way that can be done to help students in learning is assessing under the learning objectives. That is, it must allow evaluation of the extent to which they have learned. The evaluation aims to motivate students, encourage learning activities, provide guidance and feedback for remediation, select and conduct assessments using assessment instruments[3].

Based on primary observation, students of physics education department in the first semester assumes that objects with large mass fall more quickly than objects with a small mass. Scientifically, the fall time is not influenced by the mass of the object but is influenced by the height and acceleration of gravity, it can be concluded that the student experiences misconceptions. Efforts to identify
misconceptions using tests have been carried out by several researchers ranging from diagnostic tests using CBT (Computer Based Test), and two-level diagnostic tests using e-learning modern physics materials [4].

Manually using diagnostic tests can help lecturers identify factors of learning difficulties in students. In this study the authors identified misconceptions using a three-tier diagnostic test based on E-Learning on the mechanics material contained in the Basic Physics course. E-Learning has become an important trend in recent years. Based on the description above, researchers are interested in developing a three-tier diagnostic test based on e-Learning to identify students' misconceptions on mechanics.

2. Method
This research is development research with ADDIE model design. The population of this research is all physics education students in the first semester of education faculty Universitas Syiah Kuala. The sample in this study consisted of three classes selected using random sampling. Class A and C use e-learning based diagnostic tests; class B uses manual diagnostic tests. The instrument used was a three-level diagnostic test that was adopted from Hestenes (1992), as many as 29 questions, and consisted of questions, CRI index, and reasons [5]. The steps of the ADDIE model are; The analysis is the stage of identifying student misconceptions in learning physics by observing and interviewing lecturers and students so that the right solution to solve the problem is obtained. The second step is design, design an assessment one of which is a three-level diagnostic test based on e-learning on mechanics material. This activity includes translating FCI questions into Bahasa Indonesia [5]. Next is development, the stage of development of a three-level diagnostic test on mechanical material that has been designed which includes validation of three-level diagnostic test products based on e-learning on mechanical materials by experts, validation activities for the test sheet instruments that have been prepared. After that implementation, the implementation stage or testing of a three-level diagnostic test based on e-learning on the mechanics lesson in the test evaluation process is carried out at the computer laboratory which consists of three classes and provides preliminary tests to each student. Evaluation, the final stage of implementation is by giving a final test (posttest) in the two classes to find out the comparison of the extent of the success of the evaluation activities by using a three-level diagnostic test based on e-learning on mechanics lesson.

3. Result and Discussion

3.1. Analysis Phase
In the analysis phase, identification of students' misconceptions in learning physics by observing and interviewing lecturers and students, as well as references from various research articles. Based on observations of basic physics learning activities, it is known that to identify misconceptions on students requires a relatively long time. The learning and remediation process cannot be done simultaneously. The main problem is students are still experiencing misconceptions in sub topic about straight motion that has not been able to distinguish the relationship of mass objects with falling time. One solution to identify misconceptions and carry out remediation is by e-learning based diagnostic tests.

3.2. Design Stage
The next stage in this study is the design phase which consists of a three-level diagnostic test based on e-learning on mechanics lesson. This activity includes translating FCI questions from Hestenes (1992) into Bahasa Indonesia [5]. As for the instrument test lattice, the diagnostic test is in the following table 1.
Table 1. Instrument lattice diagnostic test items

| Sub Subject Material                        | Item   |
|---------------------------------------------|--------|
| Straight motion changes irregularly         | 1, 5, 12 |
| Impulse and Momentum                        | 2      |
| Regular Circular Motion                     | 3, 4, 6, 7 |
| Parabolic Motion                            | 11, 16, 17 |
| Newton's third law                          | 8, 10, 14 |
| Force                                       | 9      |
| Newton's Second Law                         | 13     |
| Irregular Straight Motion                    | 15, 18, 19, 20 |

3.3. Development Phase
The development phase includes the development of a diagnostic test instrument consisting of validation, reliability, difficulty level and different test strengths, and test revisions. The validation results show that the instrument is feasible to use with a few revisions.

3.4. Validation and Reliability of Diagnostic Tests
The instrument was corrected by experts and tested by 15 students. The instrument validation is done by providing a validation sheet of the test lattice instruments, test questions, test answer criteria, to the validator, namely the lecturer supporting the basic physics course. Based on the validator's assessment, the general assessment of the test instruments can be classified as good and can be used with a little revision. The results of testing the validity and reliability of the instrument can be seen in the following table.

Table 2. Question validation and E-learning based diagnostic test design

| Assessment                        |
|-----------------------------------|
| Material Expert                   |
| Content Feasibility               | 85%    |
| Presentation of Questions         | 86%    |
| Language Assessment               | 85%    |
| Test contents                     | 93%    |
| Format and display                | 79%    |
| Layout outline                    | 83%    |
| Packaging and evaluation activities | 85%  |
| Mean                              | 85.14% |
| Category                          | Very decent |

Based on table 2, the percentage of results of questions validation and design of e-learning based diagnostic tests from all aspects obtained values 87.25% and 82.33%. This value states that the questions and diagnostic tests that have been developed are in very good criteria which means the media is very feasible to use. The results of testing the reliability of the instrument can be seen in the table 3.

Table 3. Reliability of three-tier diagnostic test

| Cronbach's Alpha | N of Items |
|------------------|-----------|
| 0.827            | 15        |

Based on table 3, the validity of the Three Tier diagnostic test results obtained by the reliability coefficient $\alpha = 0.827$. 
3.5. Stage of Implementation and Evaluation of Diagnostic Test Instruments

In the implementation phase using an e-learning based diagnostic test for students taking part in a basic physics course, their names have appeared in the course. To see the effectiveness of diagnostic tests that have been developed can be tested on students of course too. Data from limited trials and trials is extended to guidelines for revision of e-learning based diagnostic tests that can be accessed and used by students. Design the implementation method as shown in the table below.

| Class | Stage one test | Stage two test |
|-------|----------------|----------------|
| A     | Manual         | E-learning     |
| B     | Manual         | Manual         |
| C     | Manual         | E-learning     |

Based on the results of research that has been done, it was found that three-tier diagnostic test questions based on e-learning in phase II to 56 students obtained 20 questions can be used and included in the category of valid and very reliable, difficult level, and power is different from very good category. At the stage of the activity of developing diagnostic tests based on e-learning in one subject (e.g., Basic Physics).

**Figure 1.** The front page of e-learning

If you are a lecturer at a relevant university, you can immediately develop teaching material and evaluations in the current semester. For example, after you enter e-learning, it will appear as shown in Figure 1. All programs in the current semester will appear and teaching staff can develop content or material for each meeting.

**Figure 2.** Shows the diagnostic test page
Display diagnostic test evaluation topics on the e-learning page. The test is carried out in accordance with the agreement between the lecturer and the student. The test can be done anywhere if the internet is available. The results of data collection on students’ misconceptions in this study used a three-tier test diagnostic test instrument equipped with the reasons and the Certainty of Response Index (CRI) method. The use of E-Learning in identifying student misconceptions in learning physics material mechanics can be seen from the reduction in the percentage of misconceptions experienced by students in classes A, B and C. The percentage of students’ misconceptions is shown in Figure 3.

![Figure 3](image-url)

**Figure 3.** Misconceptions of class A, B and C students

Based on Figure 3, it can be seen that the biggest misconception in class A is in item number 5 and 11 in straight motion lesson changes irregularly and parabolic motion, class B, namely item 9 and 12 straight motion changes irregularly and Newton III Law, and in-class C item 1 and 10 subject lesson Newton’s Style a and Law III. While the acquisition of the highest misconception score occurs in item 5 sub Student has not been able to determine the concept of straight motion changes irregularly on the ball thrown up, distinguish the reaction force of action, and the concept of force acting on a book located on a table. Other conditions, students have not been able to understand the concept of the circular motion of a ball shot with a cannon from the top of a cliff, and have not understood the concept of motion on rocks falling from the roof of one floor of a building to the surface of the earth.

Student’s final grades were higher in e-learning, and no differences were found in completion rates. This shows that in many aspects the effectiveness of e-learning is more effective than face-to-face learning [6]. Rosenberg (2001) Findings revealed that e-learning in addition to having weaknesses also has weaknesses, including the learning process tends towards training rather than education, as well as a tendency to ignore academic or social aspects between students [7].

Therefore to overcome this learning can be combined between e-learning with conventional learning called blended learning [8,9]. These findings are different from Louw, et al (2018), teachers tend to focus more on technology than on the learning process, and learning theories that should be the basis for this kind, of course, are often not taken into account, and that scientific approaches to teaching are often lacking [4,10]. As Price and Kirkwood (2014) correctly point out, technology can never be an agent of change: in the context of education, it is teachers who fulfil this role [4,11,12,13].

Based on the normality test, the chi test, and the t-test that has been obtained, the data obtained from both classes are normally distributed, homogeneous, and the hypothesis is accepted that the use of e-
learning based diagnostic tests are better at identifying student misconceptions than paper diagnostic tests.

| Class     | Mean | T-Test | T table |
|-----------|------|--------|---------|
| Class AB  | Pretest | 52.94  | 2.812   | 1.69   |
|           | Posttest | 47.7   |         |        |
| Class BC  | Pretest | 52.74  | 5.214   | 1.68   |
|           | Posttest | 43.46  |         |        |

### 4. Conclusions
The development of e-learning based three-tier diagnostic tests in basic physics courses using the ADDIE model has been discussed in-depth and in detail. Although the evaluation phase is at the last stage, in its implementation the evaluation phase applies at all stages. This implementation was carried out in two sessions, namely limited trials and expanded trials. Data from the trial results provide an overview of the effectiveness and ease of access to e-learning based three-tier diagnostic tests. Misconceptions of students in class A and C experienced remediation compared to class B. This shows that e-learning based three-tier diagnostic tests are effectively used to identify student misconceptions and immediately give feedback after answering all the questions.

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