Analysis of Problem Solving Ability Tests on Dynamics Material in Basic Physics Courses

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Abstract. This research aims to construct the problem solving ability test questions on basic physical dynamics material according to standards of good test qualifications in terms of validity, reliability, difficulty index and discrimination index. This type of research is development research using research and development methods of Borg and Gall model. The sample in this study were all semester 2 students physics education program of Medan state university. The results of this research indicate that of the 40 questions developed, 14 questions have met the criteria of good questions based on theoretical and empirical analysis. The fourteen questions can be used to measure the ability to solve problems with basic competence to provide solutions to the, (1) material moment of force, (2) moment of inertia, (3) equilibrium, (4) centre of gravity, (5) the law of conservation of angular momentum and (6) the application of Newton's law.

1. Introduction
Starting from children will continue to grow and develop into adolescents and adults, humans always actively solve problems that arise in everyday life. Information obtained about the surrounding environment is processed and collected into the structure of knowledge possessed both about objects, events, other people and about themselves and stored in memory. This knowledge structure includes understanding that involves mentality, beliefs, beliefs that there is an influence on how to connect experiences that are shared together and how to solve problems that arise every day, both at school, work and play areas (Chi & Glaser, 1985). Each individual must be different in solving a problem and this depends on the cognitive processes and characteristics of the ability to solve problems.

The world of work today has experienced very significant changes and is in need of individuals who can solve problems not just routine problems but are able to solve non-routine problems. Non-routine problems will familiarize each individual to use strategies in problem solving while developing other thinking skills (Gurria, 2014; Davidson, et al, 2013).

Being aware of these changes, paradigms in education really need to be adapted to changes that occur such as not just equipping students with mastery of facts and formulas but need to empower students to face and overcome complex and non-routine cognitive challenges. However, the reality is that too often teachers find that while students may excelent in routine training (which has already been seen and practiced), students fail to solve problems unlike those they found before, especially in physics. (Byundan Lee, 2014; Jonassen, 2011).

Mastering the simple steps needed to reach a solution is not enough. Students need to be lifelong learners who can handle unknown situations where the influence of the students' own intervention
cannot be predicted. When dealing with situations that require students to solve problems that do not have a standard resolution strategy, students must be able to think flexibly and creatively about how to overcome obstacles that hinder the achievement of solutions. Not just knowing what to do, but also knowing when to do it and being aware of being involved in solving the problem at hand (Docktor, et al., 2015; Gok, 2010; Kohl & Finkelstein, 2008).

One way that can be done to find out, train and develop students' physics problem solving abilities is when students are faced with problems one of which is by giving students test items that are already well standardized which contain non-routine problems that are actively involve students' thinking processes in solving problems. This is important because one of the cases that still often occurs is that tests given to students have not been able to measure the knowledge that students have and the ability to use these physical concepts in solving existing problems.

The importance of developing a well-standardized test carried out, as one way to develop education, the researcher is interested in conducting research with the aim of developing tests of physics problem solving abilities.

2. Method
This research includes the type of research and development which aims to develop tests of the ability to solve physics problems. The research and development design used refers to the Borg and Gall design with the following steps (Sugiyono, 2017; Sani, et al., 2018): (1) Preliminary studies (literature study and needs analysis), (2) research planning, (3) development of initial problem solving abilities, (4) preliminary field tests, (5) revision of limited field test results, (6) main field test, (7) revision of broad field test results, (8) operational field test, (9) revision of feasibility test results and (10) dissemination and socialization of solving ability tests final problem. This research is limited to the seventh step due to factors, time and cost.

The data needed is obtained by using literature and field studies. The literature studied is related to problem solving abilities, assessment of problem solving abilities, rubrics used to assess problem solving abilities and the development of learning outcomes tests. Based on the study of the literature, it is expected that a theoretical understanding of the physics problem solving abilities of students is obtained.

Field studies are conducted to obtain information about physics problems routinely given by teachers to students both at high school and college level to be done, so that researchers get an overview of tests of problem solving abilities that will be created and applied. The research method used is a qualitative research method where the data sources are physics teachers and students. Data collection techniques were carried out using unstructured interview methods and documentation studies.

The data analysis technique used is the qualitative analysis of the Miles and Huberman method and also quantitative which includes validity, reliability, difference power and difficulty levels. Research to find potentials and problems using qualitative methods then the data analysis will use qualitative analysis (Sugiyono, 2017). The instrument used was a problem-solving ability test developed in the form of a description. The assessment rubric used is the rubric to assess problem solving abilities Docktor, et al (2016).

3. Result
Data from the results of this study are in the form of qualitative data based on expert tests and quantitative data based on small group tests and large group trials.

3.1. Expert Judgement
Validation performed at this stage includes construct validation and content validation. The validation experts consisted of postgraduate lecturers from Medan State University, namely Nurdin Siregar
(validator 1) and Ridwan Abdullah Sani (validator 2) and one teacher senior high school, namely Iwan Panjaitan (validator 3).

The results of the initial product development test emphasize qualitative analysis, namely assessing content validation which consists of three aspects, namely in terms of construct, material and language. Constructive aspect assessment using the 3D-LAP assessment guidelines (Laverty & Caballero, 2018) the results obtained that the whole question according to the validator has met all the criteria, where the whole question has (a) presented an event, observation or phenomenon. (b) Giving or asking students to choose a claim based on events, observations or phenomena given. (c) Asking students to choose scientific principles or evidence in the form of data or observations to support claims and (d) asking students to choose reasons for why principles / concepts or evidence that support claims.

While the assessment for terms of language and material were analyzed using Aiken’s V which showed the results of 30 items that did not need revision with an index in the range 0.76 - 1.00; 8 small revision items (item number 1, 5, 18, 21, 24, 28, 34, 35, 38) with index in the range 0.51 - 0.75, and 2 large revision items (item number 32, 40) with an index in the range 0.26 - 0.50. The range of coefficient V values is between 0-1, the higher the coefficient value V, then the validation of the content of the problem is better (Aiken, 1985).

Items in the large revision category are not used for the next stage because questions number 32 and 40 are already represented by questions 34, 35, 38 for the same indicator.

3.2. Preliminary Field Tests
This small group trial was carried out after obtaining approval from the experts. This trial was carried out in the 2018 Class A Physics Education class with 33 students. Data analysis was carried out quantitatively in this study carried out using the help of a computer program, Microsoft Excel 2010. The validity of items was calculated using the Product-Moment Correlation formula. Then it is consulted with rtable at 5% significance level, so that it is known N = 33, rtable value shows the number 0.344.

Based on the results of the analysis of the 38 items, it can be seen that the questions included in the valid category are 27 items (71%). While questions that are categorized as invalid are 11 items (29%).

The reliability analysis technique used in this research is the Cronbach alpha formula technique, it is known that the reliability of the questions is 0.80, which means that the tests used already have very good reliability. The difficulty index of the tests obtained from the small group test of 27 valid questions all have difficult criteria.

The results of the small group test obtained discrimination index instrument results obtained 6 questions (16%) with sufficient criteria, 22 questions (58%) with poor criteria and 9 questions (26%) with very poor criteria. Based on the analysis of these data, the number of questions that can be used for large group trials totals 27 questions as shown in Figure 1.

![Figure 1. Follow Up on Preliminary Field Tests](image)

3.3. Main Field Test
The validity test of the large group showed 24 questions (88%) valid from 27 questions. Test reliability was calculated using Cronbach's alpha obtained 0.88 for large groups.
Meanwhile in the large group test 24 valid questions indicate difficult criteria. Discrimination index based on large group trials obtained 14 questions (52%) with sufficient criteria, 11 questions (41%) poor criteria and 2 questions (7%) with very poor criteria. The results of the follow-up based on the results of the analysis of the large group are shown in Figure 2.

**Figure 2.** Follow Up on Main Field Tests

**4. Discussion**

Based on the data analysis, it is known that 14 items can be accepted and used into the question bank to solve problem solving abilities on Newton dynamics, rotational dynamics and equilibrium. Meanwhile 9 items still need to be revised because they do not meet the good differentiation power. Whereas 4 items were discarded and could not be used because they did not meet any of the validity criteria, the level of difficulty and distinguishing features.

Item analysis is very important because it has the objective to identify good, bad and bad questions. With the analysis of the questions can be obtained information about the lack of a problem and instructions for making improvements. The problem is said to be good especially for the matter of the description, which is very related to the level of difficulty and distinguishing power (Arikunto, 2017).

This study uses modern test theory or item response theory (IRT) where the characteristics of the tests given do not depend on the test takers. IRT assumes that each test item has its own difficulty level. A person's ability level is based on the possibility that the person answered an item or group of items correctly (McCowan & McCowan, 1999).

Characteristics of item response tests are marked with two assumptions, namely unidimensional and local independence (Hambleton, Swaminathan & Jane, 1991). The fulfillment of unidimensional assumptions if there is one dominant component in influencing the ability of the subject. According to Hutten (1980) (Hattie, 1985) that unidimension can be checked by factor analysis. Unidimensional assumptions can be seen by calculating the comparison between the first and second eigenvalue. If the comparison is high, then the test is unidimensional.

Calculation of factor analysis in this study uses the help of SPSS 16.0 application whose results are shown in Figure 3. The first factor has an eigenvalue of 8.039 and the second factor of 2.885. Based on the results of the factor analysis, the comparison of the first and second eigenvalues is quite large at 5.154 as shown in Figure 3. This shows that there is one dominant factor or in other words unidimensional assumptions are met. The second assumption is that local freedom is indicated by none of the questions giving an answer to another question.

**Figure 3.** Scree Plot Factor Analysis Results
So it can be concluded that the level of difficulty of all test items with difficult criteria can still be used. The higher the level of difficult items required the higher the ability of respondents to be able to answer correctly (Sudaryono, 2011).

Producing an instrument that does not deviate from the function of the instrument is not an easy task. One thing that must be considered to get the instrument is to determine which indicators will be formulated in the form of questions (Arikunto, 2017). The instrument has high validity if the items forming the instrument do not deviate from the function of the instrument. The problem solving test in this study already has a high validity where the average validity of the constituent items is 0.491 which is greater than rtable 0.206.

The duration of testing required is the same for a small group test or a large group test. Time allocation is determined according to the need for achievement of basic competencies and learning burdens, 1) Available time and 2) The nature of the material being tested is something that must be considered in determining the form of the test (Arikunto, 2017).

Based on observations made during the research in the field as well as the results of the analysis of student answers it can be concluded that the ability of solving students' physics problems still needs to be improved. Conditions obtained in the field of the test takers tend to focus on solving one problem first so that the time spent working on other questions is not met. Test participants' answers on the test sheet showed a lack of ability to understand the problem physically and to plan solutions based on physical concepts such as procedures for the ability to solve problems they should. Test participants tend to use the formula directly and enter the numbers that have been listed in the questions. This is in line with research conducted by Misbah (2016). In addition, it is also obtained that although the test taker is able to show the solution and write the unit well, the ability to identify the coordinate axis, draw a free diagram, illustrate the direction of the force is still unsatisfactory. This situation is also in line with research conducted by Supeno, et al (2018).

Improving problem solving ability can be done by creating appropriate learning to be able to facilitate students to improve their abilities. In addition, the improvement of questions is needed by analyzing both qualitatively and quantitatively to get quality questions. The ability to analyze the items must continue to be developed because doing the analysis is difficult work, requires hard work. Analysis requires creative power and high intellectual abilities (Sugiyono, 2017).

5. Conclusion

Research and development of Problem Solving Ability Tests on Newton Dynamics, Rotational Dynamics and Equilibrium by using the Borg and Gall research and development model that has been carried out by accepting, considering and making improvements, conclusions are obtained, the validity of the problem solving ability test on developed at Newton's Dynamics, Rotational Dynamics and the Equilibrium are obtained at the "valid" level where: (a) Analysis of 40 items of description after a small group test and a large group test obtained a small group validity test showing 27 questions (71%) valid from 38 questions that have passed content validation by experts. While the validity test of large groups showed 24 questions (88%) valid from 27 questions.

Reliability Tests for problem solving skills in Newton's Dynamics, Rotational Dynamics and Equilibrium developed material were found at the "very good" level. Test reliability was calculated using Cronbach's alpha obtained a number of 0.80 for small groups and 0.88 for large groups.

Difficulty level Tests for problem solving skills on Newton Dynamics, Rotational Dynamics and Equilibrium developed are found at the "difficult" level. The level of difficulty of the tests obtained from the small group test of 27 valid questions all have difficult criteria. Likewise in the large group test 24 valid questions also indicate difficult criteria.

Discrimination index test of problem solving ability on Newton's Dynamics, Rotational Dynamics and Equilibrium developed for small group test results obtained different test instruments with 6 questions (16%) with sufficient criteria, 22 questions (58%) with poor criteria and 9 questions (26%) with very poor criteria. While the large group test obtained 14 questions (52%) with sufficient criteria, 11 questions (41%) were poor criteria and 2 questions (7%) with very poor criteria.
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