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DEVELOPMENT OF PROBLEM-SOLVING INSTRUMENTS TEST AT ROTATIONAL DYNAMICS AND EQUILIBRIUM OF RIGID BODIES TOPIC

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Abstract

The ability to think at a higher level (HOTS) refers to the cognitive thinking process of students at a higher level, which evolves from various cognitive concepts and learning taxonomies, such as problem-solving methods. Based on the observations conducted by researchers at SMAN 5 Medan, the current assessment does not prioritize problem-solving skills. This research aims to develop a test instrument that can measure problem-solving skills in students with a high level of validity and reliability. The method used in this development is the research and development model ADDIE (Analysis, Design, Development, Implementation, and Evaluation). In summary, the steps in this development include 1) problem identification and analysis. 2) designing a problem-solving test instrument. 3) developing the problem-solving test instrument to a suitable level. 4) testing the problem-solving test instrument on a small and large scale. 5) analysis the validity of the test instrument and the quality of test items. The result of this research is a developed problem-solving test instrument in the form of essays, meeting the criteria for a high-quality test instrument, and suitable test items.

Keywords: Analysis, Equilibrium, Instrument test, Rotational Dynamics, Problem-solving

INTRODUCTIONS

At present, Indonesia faces the challenges of development that demand greater efforts than many other countries. Indonesia is the world's largest archipelagic nation, with a large population and abundant natural resources. To compete in this demanding era, Indonesia must have high-quality human resources. The quality of human resources is crucial because it determines the progress of a nation.

Education plays a pivotal role in enhancing the quality of human resources. The 2003 Law on the National Education System provides the basic framework for education in Indonesia. Education is divided into two main types: formal education (including primary, secondary, and tertiary education) and non-formal education (such as courses, training, and self-development).

Education is at the core of everyday life, providing knowledge spanning various aspects, from social and cultural to religious and scientific and technological knowledge. Education also prepares human resources to adapt to changing times and compete on the global stage by developing intellectual, problem-solving, and problem-solving skills.

Physics is one of the subjects taught at the secondary level and requires in-depth understanding of natural phenomena and accurate measurement. In physics education, it is essential to develop higher-order thinking skills (Higher Order Thinking Skills, HOTS) such as problem-solving and problem-solving.

The importance of HOTS-based test instruments becomes evident as they assist teachers in assessing students' understanding more comprehensively. With the development of more HOTS-based test instruments, teachers can provide more accurate assessments and help students develop higher-order thinking skills like analysis, evaluation, and creation. Thus, education and the development of HOTS-based test instruments play a key role in preparing high-quality human resources for Indonesia's future.

Based on the introduction, the researcher has decided to conduct a study titled "Istruments of Problem-solving Test at Rotational Dynamics and Equilibrium of Rigid Bodies Topic".

METHODS

The research was conducted at SMAN 5 Medan, located at Jl. Pelajar No. 17, Kec. Medan Kota, Kota Medan, Sumatera Utara, in September 2023. The sample for this study consisted of 51 students from two Class X classes, namely Class X-1 with 28 students and Class X-2 with 23 students. The research method used was the Research and Development (R&D) model ADDIE, which consists of five stages of development: analysis, design, development, implementation, and evaluation.

- Analysis Stage: The researcher conducted observations and interviews with Mrs. Eskaria Sirait, S. Pd., to identify the issues existing at SMAN 5 Medan and find solutions to address them. After determining the development of a problem-solving test instrument as a solution, the researcher then analysis the core competencies and basic competencies from the syllabus as the foundation for developing the problem-solving test instrument.
- Design Stage: The researcher designed the test format, the number of test items, the blueprint (kisi-kisi), scoring guidelines, answer keys, validation questionnaires for evaluation by experts, and questionnaires for student responses.
- Development Stage: The researcher carried out the creation and testing of the problem-solving test instrument developed with input from validators and students. This process involves refining and validating the instrument to ensure their quality and effectiveness.
- Implementation Stage: The researcher pilot-tested the problem-solving test instrument on a sample of participants.
- Evaluation Stage: It can be done at any stage because the activities in the evaluation phase involve evaluating and correcting any errors to produce a better high-level thinking test instrument.

RESULTS AND DISCUSSION

Analysis Stage

- Core Competence
    - KI3: Understanding, applying, and analysis factual, conceptual, and procedural knowledge based on their curiosity about science, technology, arts, culture, and humanities with a humanistic, national, and civilizational perspective related to the causes of phenomena and events, and applying procedural knowledge in specific areas of study according to their talents and interests to solve problems.
    - KI 4: Processing, reasoning, and presenting in both the concrete and abstract realms related to the development of what is learned in school independently, and acting effectively and creatively, as well as being able to use methods in accordance with scientific principles. Basic Competence
    - KD 3.3: Applying concepts of torque, moment of inertia, center of gravity, and angular momentum to rigid bodies (static and dynamic) in daily life, such as in sports.
    - KD 3.4: Creating works that apply the concepts of the center of gravity and equilibrium of rigid bodies.

Design Stage

During the planning stage, the researcher designs the problem-solving instrument to be developed by preparing a blueprint, scoring guidelines, expert validation questionnaires, and student response questionnaires.

- Problem-solving Test Instrument

  The problem-solving test instrument to be developed will consist of 5 essay questions on the topics of rotational dynamics and equilibrium of rigid bodies.
- Validation Questionnaire by Validators

  Three validators were chosen, namely: 1) Abdul Rais, S. Pd., S. T., M. Si., 2) Rajo Hasim Lubis, M. Pd., and 3) Dr. Ridwan Abdullah Sani, M. Si.
- Student Response Questionnaire

  The student response questionnaire or small-group testing was employed to assess the appropriateness of the developed problem-solving test instrument for student evaluation.

Development Stage

- Validity from Validator

  From three validators that were chosen, all of the validators assessed the problem instruments test as essential (A and B). To determine the validity coefficient by validators, you can use the content validity ratio equation.

$$\mathrm{CVR} = \frac{\mathrm{ne} - \frac{\mathrm{N}}{2}}{\frac{\mathrm{N}}{2}} \quad (1)$$

  The outcome obtained from formula (1) is 1,0. Since the CVR result is equal to or greater than 0,5, it is reasonable to deem the problem-solving test instrument as valid for utilization.
- Student Response Test

  The data gathered from the student response test yielded a cumulative score of 530 across 10 categories. The Likert equation was applied to calculate the coefficient.

$$\mathrm{URS} = \frac{\sum \mathrm{x}}{\mathrm{N}}\ 100\% \quad (2)$$

  The outcome obtained from formula (2) is 85.3125% is obtained. This suggests that the problem-solving test instrument exhibits an exceptionally high level of suitability and effectiveness for use by students, underlining its robust validity and reliability for assessing their problem-solving skills.

Implementation Stage

- Validity

  The authors conducted a comprehensive group test and computed the results using standard deviation. The outcome of the first test was found to be 9.947 x 10^-14, while the second test yielded a result of -4.973 x 10^-14. These values were subsequently used to calculate the variances, leading to a variance of 683.0484 for the first test and 621.4193 for the second test.

  To determine the validity of the results obtained from the extensive group test, the authors followed the equation recommended by Supriyadi (2011). This equation likely encompasses various statistical or analytical methods for assessing the validity of the data, as detailed by Supriyadi.

$$\mathrm{V} = \frac{\sum \mathrm{x}\prime.\mathrm{y}\prime}{\sqrt{\sum \mathrm{x}\prime^2.\sum \mathrm{y}\prime^2}} \quad (3)$$

The outcome obtained from formula (3) is 0,755074888, this indicates that the test instrument's validity can be characterized as reasonably valid. In other words, the instrument demonstrates a level of validity that is acceptable and can be relied upon with confidence for its intended purpose. While it may not represent the highest level of validity, it still provides a reasonable and trustworthy measure for its designated use.

- Reliability

The equation used for assessing the internal reliability of a test instrument is known as Cronbach's Alpha equation. This particular formula is a widely recognized and respected method for evaluating the consistency and reliability of a test or measurement tool. It helps to determine how well the individual items or questions within the test are related to one another. In other words, it measures the degree of correlation or consistency among the various items that make up the test. This equation's application provides valuable insights into the reliability of the test instrument, ensuring that it can consistently and dependably measure what it's designed to assess. Hidayat (2014) is a reputable source that explains this method in more detail.

$$r_{11.1} = \frac{n}{n-1}\left(1 - \frac{\sum x_i'^2}{x'^2_t}\right) \quad (4)$$

$$r_{11.2} = \frac{n}{n-1}\left(1 - \frac{\sum y_i'^2}{y'^2_t}\right) \quad (5)$$

$$r_{xy} = \frac{N\sum xy - \sum x \sum y}{\sqrt{\left((N\sum x^2) - (\sum x)^2\right)\left((N\sum y^2) - (\sum y)^2\right)}} \quad (6)$$

In the first test, the authors determined the variance of the scores for each individual test item, resulting in a value of 3.946853517. The variance of the total score for this test was calculated to be 11.19751454. When the authors applied equation (4) to these figures, it yielded a result of 0.809405181. This value signifies that the internal reliability of the first test falls within the "good" category, indicating that the test items are consistent and dependable in measuring the intended construct.

For the second test, the authors calculated the variance of the scores for each test item, resulting in a variance of 3.078341014. The variance of the total score for this test was found to be 10.18720254. Using equation (5), the result was computed as 0.872278417. This outcome indicates that the internal reliability of the second test is categorized as "high," suggesting a strong consistency and reliability of the test items in measuring the targeted construct.

When considering both the first and second tests together, the authors determined a total score of 981 for the first test and 924 for the second test. The total squared result for the first test was 16,205, and for the second test, it was 14,392. By applying equation (6), the result was determined to be 0.755074888. This finding indicates that the internal reliability of the first test still falls within the "good" category.

Overall, the results suggest that both tests exhibit a high degree of external reliability. This means that these tests consistently measure the same construct or trait across different occasions or conditions, indicating their robustness and dependability as measurement tools.

- Difficculty Level of Test Items

To distinguish individuals into the upper group (Ka) and lower group (Kb), it is necessary to compute the average scores for each test item derived from the first two tests. The average scores for the upper group are as follows: 67, 64.5, 70, 61.5, and 59. Conversely, the average scores for the lower group are 39.5, 38.5, 43.5, 36, and 34.5.

The difficulty level of test items is determined based on the results of large group testing. This assessment is carried out according to the guidelines established by Supriyadi (2011). The specific equation used for this purpose is provided below, and it helps in categorizing the test items by their level of difficulty. This information is valuable for understanding how challenging or accessible each test item is for the examined groups.

$$P = \frac{SKa+SKb}{SmaxKa+SmaxKb} \quad (7)$$

The results generated by formula (7) are as follows: 0.626470588 (P1), 0.605882353 (P2), 0.667647059 (P3), 0.573529412 (P4), and 0.55 (P5). These values indicate that the difficulty level of all five test items falls within the "moderate" category. This suggests that the test items are moderately challenging, making them suitable for assessing the abilities of the examined groups without being overly difficult or too easy.

- Discriminatory Power of Test Items

The data derived from the average scores for each test item are crucial for evaluating the discriminatory power of these items. This assessment aims to understand how effectively each test item can distinguish between individuals with different levels of ability. To perform this assessment, Supriyadi (2011) offer a specific equation that helps in quantifying the discriminatory power of the test items based on the results of large group testing. This information is valuable for determining whether the test items are effective in discriminating between high and low performers, aiding in the identification of the most challenging items.

$$D = \frac{\sum Ka - \sum Kb}{S_{maks}} \quad (8)$$

By using equation (8), the assessment of item discrimination power serves the purpose of evaluating the test's effectiveness in distinguishing between students with varying levels of ability. This evaluation is crucial to determine whether the test can accurately identify and separate high-ability students from their low-ability counterparts.

The results of the discrimination power test yield discrimination power coefficients for each of the five test items. Specifically, for item 1, the coefficient is 0.323529412; for item 2, it is 0.305882353; for item 3, the coefficient is 0.311764706; item 4 records a coefficient of 0.3, and item 5 shows a coefficient of 0.288235294. These coefficients are a numerical representation of each item's ability to distinguish between students with different levels of ability.

The significance of these coefficients lies in their collective indication that the developed test instrument meets the criteria for being a good test. In other words, it effectively and accurately discriminates between high-ability and low-ability students, making it a reliable tool for assessing and categorizing students based on their capabilities.

CONCLUSION

Upon a thorough examination of the research and the comprehensive discussions presented, the following detailed conclusions can be drawn. Firstly, the problem-solving instrument developed for the topic of rotational dynamics and the equilibrium of rigid bodies in grade XI at SMAN 5 Medan was meticulously crafted using the ADDIE development model. This model provided a structured framework for the development process, ensuring the instrument's effectiveness, alignment with the curriculum, and relevance to the students' specific needs.

Secondly, the problem-solving test instrument, comprising 5 essay-type test items, exhibits several characteristics that categorize it as a high-quality assessment tool. It demonstrates reasonably good validity, falling within the "reasonably valid" category, signifying its effective measurement of the targeted skills and knowledge. Furthermore, the test shows a high level of reliability, consistently producing dependable results when administered to the same group of students under similar conditions.

Additionally, the research encompassed the development of a critical thinking test instrument, which also meets specific criteria. The item analysis conducted on the critical thinking test unveiled crucial insights. The test items exhibit a moderate level of difficulty, effectively balancing between being excessively easy or overly challenging, thus appropriately suited to assess students' critical thinking abilities. Moreover, the test items display a high level of discrimination power, indicating their effectiveness in distinguishing students with varying levels of ability or knowledge in the subject matter.

In summary, this research has yielded robust problem-solving and critical thinking test instruments designed for grade XI students at SMAN 5 Medan. These instruments have undergone stringent validation processes and item analyses, confirming their quality, effectiveness, and appropriateness for assessing students' abilities and knowledge.

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