

Developing of Hots Test Instruments in Computer-Based Exams on Rotational Dynamics and Rigid Bodies

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Abstract: Higher-Order Thinking Skills (HOTS) based questions can train students to develop their reasoning power. Therefore, this study aimed to obtain a HOTS-based test instrument in a feasible computer-based exam on the topic of rotational dynamics and rigid body balance. The research method used in this development research is 4-D, consisting of four stages: define, design, develop, and disseminate. The result of this research is the HOTS-based test instrument in a computer-based test that is feasible on the material of rotational dynamics and rigid body balance that meets the validity requirements of material experts and media experts with the lowest V index value of 0.58 and the highest V index value equal to 0.83. The average percentage of the total validation score of material experts obtained was 77.78%, and media experts was 79.44%. Overall, the test instrument has a total media validation score of 78.61%, so that the computer-based HOTS test instrument with testing based on rotational dynamics and rigid body balance is categorized as valid and ready to use.

Keywords: HOTS, test instrument, computer-based exam, rotational dynamics, rigid body.

Given the 2013 curriculum, the learning process of students was intended to develop the potential possessed by students from various aspects, namely attitudes (affective), knowledge (cognitive), and skills (psychomotor). The learning process in the 2013 curriculum was student-centered or center learning, so that students are required to be active in finding and finding answers to the problems they face in the learning process, which makes students trained in higher-order thinking skills (HOTS) (Rizki et al., 2020).

Students who have low-level thinking skills without higher-order thinking exercises cause the learning process of students to be incomplete (Yee et al., 2015). Therefore, it takes an instrument that can be used by students to improve higher-order thinking skills. The instrument is in the form of a test whose completion requires higher-order thinking skills or what we are more familiar with HOTS-based tests (Heong et al., 2012).

In compiling a test, material selection is of course the main thing. The material of rotational dynamics and rigid body balance is very closely related to logical thinking in everyday life. This of course can stimulate students in improving higher-order thinking skills. Based on the author's

observations on the year-end assessment test questions, questions regarding the rotational dynamics and rigid body balance materials generally only make students look for the value of an object. There were no questions that make students analyze or assess a case or statement. In general, the questions used by schools in Indonesia as a cognitive assessment instrument were questions that tend to aim to test more aspects of memory (Kusuma et al., 2017; Subagiyadi et al., 2020). Meanwhile, the questions intended to train students' higher-order thinking skills are very limited. Therefore, it is necessary to develop questions or test instruments that can measure students' higher-order thinking skills.

There have been many previous studies that have developed HOTS-based questions, but the instrument is still conventional, such as the development of the HOTS assessment instrument to measure the dimensions of students' science knowledge in junior high schools conducted by Julianingsih et al. (2017), the development of the 2013 curriculum-based HOTS assessment instrument for the disciplined attitude carried out by Pratiwi & Fasha. (2015), or the development of the mathematics learning outcomes test instrument for

elementary school students oriented to higher-order thinking conducted by Ndiung & Jediut (2020), and many other similar studies, but still rarely develop it in the form of computer-based questions.

Along with the times, especially in the field of technology and information, the test format has also developed. Especially in the current COVID-19 pandemic conditions, all learning activities including exams were carried out online (*daring*). The exam format which was originally conventional (paper test) began to shift into a form of electronic questions based on computers and the internet. Therefore, the research on instrument development in the form of developing HOTS-based test instruments in computer-based exams is considered to be one solution in keeping up with existing technological developments, with case studies on rotational dynamics and rigid body balance material, which were tested on XI grade high school students.

METHOD

The research method used to develop the HOTS-based test instrument in computer-based exams on the material of rotational dynamics and rigid body balance is the research and development (R&D) method. In conducting research, researchers do not need a special place to conduct research. The facilities needed in this research were only in computers, books, scientific journals, and internet access. The research model used in this development research was 4-D. The 4-D development model consists of several stages, namely: (1) define, (2) design, (3) development, and (4) disseminate. However, in this study, researchers only arrived at the third stage, namely development.

The data collection method was used a product evaluation questionnaire. The questionnaire collects data through researchers asking written questions and then answering with written answers. The questionnaire was used as a parameter of the feasibility of the HOTS-based test instrument in a computer-based test on the rotational dynamics and rigid body balance material developed by the researcher. In addition, the questionnaire can also be used as a source of improvement from the HOTS-based test instrument in a computer-based test on rotational dynamics and rigid body balance material developed by the researcher. The questionnaires were given to two research subjects, namely material experts and media experts, each of which consisted of five experts.

The research data were analyzed using descriptive analysis. The material expert and media expert validation sheets during product testing were used to provide quality criteria for the developed product and to revise the developed test instrument. Expert validation questionnaires were arranged with an interval scale of 1 to 5. The quantitative data was converted into qualitative data. Validation data analysis was carried out by finding the Aiken V index using the equation:

$$V = \frac{\sum s}{n(c-1)} \tag{1}$$

Where V is the agreement index of the validator regarding item validity; s score obtained from the validator minus the lowest score in the category used ($s = r - l_0$, where r = score obtained from the validator and l_0 the lowest score in the scoring category); n number of validators; and c the number of categories that can be selected by the validator. The V index was between 0-1. An item or device can be categorized based on its large index. If the index was less or equal to 0.4 then the validity was less, if the value was between 0.4–0.8 then the validity was moderate, and if it was greater than 0.8 then it was very valid (Retnawati, 2016).

Furthermore, based on the data from the results of the validity assessment of the instrument, the average value of the indicators given by each validator was determined.

Rating of the nth validator:

$$V_{a-n} = \frac{TS_{e-n}}{TS_h} \times 100\% \tag{2}$$

Average validation total score:

$$V_t = \frac{V_{a-1} + V_{a-2} + V_{a-3}}{3} \tag{3}$$

- V_{a-n} = the value obtained from the nth validator
- TS_e = total score obtained from the nth validator
- TS_h = max total score
- V_t = average validation total score

The total mean value of (V_t) was referred to the interval determining the level of validity of the test instrument as shown in Table 1.

Table 1. Expert Validation Criteria

No.	Percentage (%)	Remarks
1	81% - 100%	Very valid
2	61% - 80%	Valid
3	41% - 60%	Quite valid
4	21% - 40%	Invalid
5	0% - 20%	Very invalid

RESULTS AND DISCUSSION

Results

The product produced in this development research is the HOTS test instrument as a computer-based test item on the material of rotational dynamics and rigid body balance. The validation results from material experts and media experts are presented in Tables 2 and 3, while the average validation from the two experts can be seen in Table 4. The display of product development results before and after revision can be seen in Figures 1 and 2.

Table 2. Material Expert Validator Assessment Results

No.	Assessment Aspect	Aiken V Index
Content Eligibility		
1	Conformity with core and basic Competencies	0.75
2	The truth of the material presented	0.83
3	Homogeneous and logical answer choices	0.83
4	Conformity with higher-order thinking aspects	0.75
5	Relevance to everyday problems	0.67
Language		
6	The language used meets the readability aspect	0.75
7	Conformity with Indonesian language rules	0.75
8	The simplicity of sentence structure	0.75
9	The communicative nature of the language used	0.58
Presentation		
10	Time allocation according to the number of questions	0.67
11	Have complete information	0.58
12	Picture/illustration according to the purpose of the question	0.75

Table 3. Media Expert Validator Assessment Results

No.	Assessment Aspect	Aiken V Index
Graphics		
1	Illustration support to clarify activities	0.67
2	Have visual appeal	0.58
3	Have a clear view	0.75
4	Layout space setting	0.75
5	Compatibility of font type and size	0.83
6	Image clarity	0.67
7	Clarity of formula writing	0.75
Presentation		
8	Presented in an attractive way	0.67
9	Have complete information	0.75
10	Easy to understand	0.83
11	Provides a visual boost	0.83
Use		
12	Easy to use	0.75
13	Compatibility (the instrument can run on various devices)	0.75

Table 4. Average Result of Expert Validation Total Score

Aspect	Average	Criteria
Material	77.78%	Valid
Media	79.44%	Valid
Total	78.61%	Valid

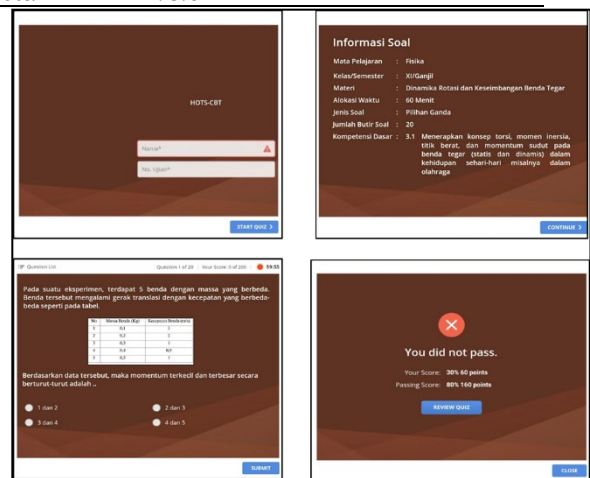


Figure 1. Display of the initial design of the test instrument



Figure 2. Instrument display after revision

DISCUSSION

The results of the development of the HOTS test instrument as a computer-based exam on the material of rotational dynamics and rigid body balance have been validated by material experts and media experts, with the results as shown in Tables 2 and 3. Based on the data obtained with an average of 77.78% and 79.44% (Table 4), indicating that both values are in the valid category. This shows that the instrument that has been developed can be a choice for computer-based exams to measure students' higher-order thinking skills, especially in the matter of rotational dynamics and rigid body balance. The instruments developed were valid both materially and from a media perspective. The results of this study support the statement Szymkowiak et al. (2021) which states that in the era of increasingly advanced technology as it is today, the form of test instruments must be computer-based, especially in the current state of the COVID-19 pandemic. Zohar (2013) and Kwangmuang et al. (2021) also reveal that it is important to develop HOTS test questions, as a way of thinking at a higher level than memorizing or retelling something that has been told by others, so that with HOTS the ultimate goal of learning activity can be achieved. achieved through the approach, process, and method of learning itself.

Three aspects were assessed in terms of material, namely aspects of content feasibility, linguistic aspects, and aspects of the presentation. The results of the assessment by the material expert validator for each aspect studied were presented in Table 2. The aspect with the highest score is obtained in the truth section of the material presented and the answer choices were homogeneous and logical with a V Aiken index of 0.83. This is the strength of the developed instrument. In line with the theory of truth in a philosophical perspective as expressed by Atabik (2014) that it is important to put forward a truth value in all aspects, including the transfer of knowledge from educators to students. Meanwhile, in terms of homogeneous and logical answer choices, it is also by the guidelines for making test instruments in general. The aspect with the lowest score is in the communicative nature of the language used and the completeness of information with a V Aiken index of 0.58. However, both aspects have been improved by adding instructions for doing the questions as shown in Figure 2.

In the material expert validation, there are three aspects that were assessed, namely the aspect of content feasibility with five assessment points, the linguistic aspect with four assessment points, and the presentation aspect with three assessment points. Thus there are twelve items that must be assessed by the material expert validator. In the aspect of content feasibility, there are three assessment items with moderate validity, namely on the item relationships with everyday problems with an index V of 0.67. Then the other two items, namely the item conformity with core and basic competencies and conformity with higher-order thinking aspects obtained an index V of 0.75. Furthermore, for the highest V index of 0.83 on the items "truth of the material presented and homogeneous and logical answer choice items. The two items are categorized as very valid because the value of the V index is greater than 0.8. In all items of the content feasibility aspect, the researcher did not make changes because there were no items that had a low level of validation and there was also no suggestion from the validator to replace some questions so that the researchers considered that the content feasibility aspect was appropriate.

In the linguistic aspect, all the assessment items have moderate validity because the index value is between 0.4-0.8. The lowest index in the linguistic aspect is owned by the item "communicative nature of the language used" with a V index value of 0.58. Furthermore, the other three

assessment items have a V index of 0.75 which is owned by the items the language used meets the readability aspect, compatibility with Indonesian language rules, and simplicity of sentence structure. Similar to the content feasibility aspect, the linguistic aspect did not make any changes.

In the aspect of presenting all assessment items, the validity results are moderate because the index value is between 0.4-0.8. In the assessment aspect, there are three assessment items, each of which has a different V index value. The item allocation of time according to the number of questions has a V index value of 0.67, the item has complete information" has a V index value of 0.58, and the item pictures/illustrations according to the purpose of the question has the highest V index value, of 0.75. In this aspect of the presentation, the researcher made many revisions to the instrument. The revisions made by the researchers included changing the time for working on the questions based on the level of difficulty of the questions, adding a page of instructions for working on the questions before entering the first question, and some adjustments to the pictures/illustrations.

In terms of media expert validation, three aspects were reviewed, namely aspects of graphics, presentation, and use. The highest index is in the aspect of graphics and presentation with elements of the suitability of type and size of letters, ease of understanding, and visual encouragement with a V Aiken index value of 0.83. Visual attractiveness is the element with the lowest V Aiken index with a value of 0.58. This has been overcome by adding a lighter color variation, which was previously brown (Figure 1), after being revised to a combination of blue, yellow, and red with white writing as shown in Figure 2. Therefore, it is important to make an interesting learning product, including one in terms of design and visual color combinations. Nurseto (2011) and Fatihah et al. (2020) also said that an interesting product can be a stimulus for its users, in this case, students.

In media expert validation there are three aspects that were assessed, namely the graphic aspect with seven assessment points, the presentation aspect with four assessment points, and the usage aspect with two assessment points. Thus there were thirteen items that must be assessed by media expert validators. In the graphic aspect, there is one item that is included in the very valid category with a V index value of 0.83, namely on the item suitability of type and font size. Then the remaining six items are in the category of moderate validity. In the medium category, there is one item that has the

lowest index value of 0.58 on the item has visual appeal. This item has the lowest index value because according to the validator the background used in the instrument is not attractive or does not match the expectations of the validator, therefore the researcher changes the background of the instrument to be more colorful and attractive. Furthermore, on the item clarity of images and illustration support to clarify activities, obtaining an index of 0.67 is because there are some images/illustrations that are not clear. Therefore, the researcher made changes to some pictures/illustrations and made pictures/illustrations according to the background used. Then the last three items, namely the item has a clear appearance, layout space arrangement and clarity in formula writing have a V index value of 0.75. In these three items, the researcher did not make any changes because they were deemed appropriate, as evidenced by the value of the V index almost touching the very valid category.

In the presentation aspect, there are two assessment items with very valid categories so that the researcher considers no changes to these items are needed. The assessment points in question are the items easy to understand and providing visual encouragement which have a V index value of 0.83. Furthermore, on the item has complete information with a V index value of 0.75, the researcher did not make changes, only moved the information display to the initial page of the instrument in accordance with the suggestions from the validator. Then the item presented in an attractive way has a V index value of 0.67 this is because the instrument developed by the researcher has a monotonous background color composition so that changes must be made, namely by changing the background.

In the presentation aspect, namely on the items easy to use and compatibility (the instrument can be run on various devices), all compact validators gave the same value, namely 4 which means valid, so the researcher did not make changes to these aspects because all items had an Aiken index value of V of 0.75. Overall, the HOTS-based test instrument in the computer-based test on rotational dynamics and rigid body balance material has an average total validation score of 78.61% in the valid or usable category but needs minor revisions. The suitability of the questions with the purpose of developing the instrument, the truth of the material presented, being easy to understand, and having visual encouragement are some of the factors that cause the validity of the test instrument.

Based on the results of the validation of material experts and media experts, the total average validation score for the HOTS-based test instrument in computer-based exams on rotational dynamics and rigid body balance material as a whole is 78.61% with valid categories as shown in Table 4. The results concluded that the HOTS-based test instrument in the computer-based test on the rotational dynamics and rigid body balance material developed was classified as good. This is because the instrument preparation process is carried out by the stages such as initial analysis, material analysis, formulating goals, compiling grids, following questions, making instruments so that they can produce HOTS-based test instruments in computer-based exams on rotational dynamics and balance material. appropriate rigidity. In addition, with several revisions that have been made by researchers based on suggestions from experts, the test instruments developed are better, so that the HOTS-based test instruments in computer-based tests on the material of rotational dynamics and rigid body balance are feasible and ready to be used.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the results of this study are that the HOTS-based test instrument in a computer-based test is feasible on the material of rotational dynamics and rigid body balance. The instrument has met the validity requirements of material experts and media experts with the lowest V index value of 0.58 and the highest V index value of 0.83. Furthermore, the average percentage of the total score of material expert validation obtained is 77.78%, and media expert is 79.44%, and overall, the test instrument has an average total validation score of 78.61%. Thus, the HOTS-based test instrument in the computer-based test on the material of rotational dynamics and rigid body balance is in the valid category and is ready to be used.

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