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Development of a Physics Assessment Instrument to Measure High School Students Multirepresentation Skills in Momentum and Impulse

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ABSTRACT

This research is a Research and Development. Developed a multirepresentation test instrument to measure the multirepresentation skills of class XI students specializing in physics at SMA Negeri 1 Semarang on momentum and impulse. This was done because the multirepresentation skills of SMA Negeri 1 Semarang students had not been measured as a whole and maximally. The multirepresentation test instrument has been tested for suitability by experts and small-scale trials have been carried out on students. Based on the results of validity, reliability, level of difficulty and differentiability tests, 25 questions were obtained that were suitable for use in the field. The overall average percentage results of multirepresentation skills for class XI students specializing in physics at SMA Negeri 1 Semarang is in the good category with a percentage of 76.89%. Based on these results, the multirepresentation test instrument is suitable for use to measure students' multirepresentation skills as evidenced by students' multirepresentation skills being measured well to the instrument developed.

INTISARI

Penelitian ini merupakan penelitian pengembangan. Mengembangkan instrumen tes multirepresentasi untuk mengukur keterampilan multirepresentasi siswa kelas XI peminatan fisika SMA Negeri 1 Semarang pada materi momentum dan impuls. Hal ini dilakukan karena keterampilan multirepresentasi siswa SMA Negeri 1 Semarang belum terukur secara menyeluruh dan maksimal. Instrumen tes multirepresentasi telah dilakukan uji kelayakan oleh para ahli dan telah dilakukan uji coba skala kecil kepada siswa. Berdasarkan hasil uji validitas, reliabilitas, tingkat kesukaran dan daya beda diperoleh 25 soal yang layak digunakan di lapangan. Rata-rata keseluruhan hasil presentase keterampilan multirepresentasi siswa kelas XI peminatan fisika SMA Negeri 1 Semarang berada pada kategori baik dengan presentase sebesar 76,89%. Berdasarkan hasil tersebut maka instrumen tes multirepresentasi layak digunakan untuk mengukur keterampilan multirepresentasi siswa yang dibuktikan dengan keterampilan multirepresentasi siswa yang terukur dengan baik terhadap instrumen yang dikembangkan.

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A. Introduction

One of the orientations of the independent curriculum includes an approach to education that aims to provide students with independence in learning, so that students can develop their potential optimally [1]. According to Marta & Vallindra [2], evaluation in the independent curriculum does not separate the three assessment domains, namely behavior or attitudes, skills, and knowledge and has an emphasis on behavior on the Panacasila student profile. The independent curriculum has types of assessments, namely diagnostic assessments, formative assessments, and summative assessments. The output of these types of assessments is one of the guidelines in deciding a student's achievement. Based on the assessment technique, the assessment instruments in the independent curriculum include written tests, oral tests, observations, projects, performance, portfolios, and assignments.

Permendikbud No. 21 of 2022 concerning Education Assessment Standards states that learning outcomes cover three domains, namely by educators, educational units, and the government. The purpose of the assessment is to evaluate all learning processes [3]. According to Susilaningsih [4], cognitive assessment is one of the things that needs to be considered regarding its quality. Instruments in assessment as a means or tool used to collect data and information [5]. The type of assessment carried out is by giving tests to students [6].

Sulistyowati [7] said that skills are the ability to operate a job quickly and easily. The scope of skills is very broad, such as action skills, thinking skills, speaking skills, seeing and hearing skills, and so on Nasihudin & Hariyadin [8]. One of the existing skills is multi-representation skills. Multi-representation skills are very important to support student learning outcomes because they can be used as a benchmark for students in representing a physics problem.

One of the inseparable parts of science is representation [9]. The multi-representation approach is an approach that primarily emphasizes a meaning in the form of verbal representations, images, equations, diagrams, tables, and graphs, so that it can help improve the evaluation process in the physics learning process [10].

Although in physics learning multi-representation ability is very important, but in the application in the field, learning carried out in the classroom still does not orient multi-representation skills in students [11]. This is found in a study conducted by Furqon & Muslim [12] which stated that the representation ability of students is still very low. According to Amaliah & Purwaningsih [13] The low representation ability occurs because the understanding of concepts in physics is also low.

The improvement of students' representational abilities in learning activities has been carried out with various efforts. According to Sirait [14] The final results of the correct multi-representation assessment in learning can improve students' representational abilities. Based on this, the development of physics assessment instruments to measure students' multi-representation skills is an important part to be

developed so that students can interpret problems in physics [15]. Therefore, it is necessary to develop an evaluation tool in the form of physics test questions that are useful for measuring students' multi-representation abilities in solving physics problems.

The development of physics assessment instruments to measure multi-representation abilities has been carried out by several researchers. However, many of the instruments developed only measure several multi-representation abilities, such as the research conducted by Ceuppens [16] which only developed multi-representation instruments in three forms of representation, namely graphs, tables, and equations.

Based on these facts, instruments that can measure more multi-representation abilities need to be developed. The instrument development that will be carried out is in the form of multiple-choice test questions. The representations that will be developed are in the form of verbal representations, images, equations, diagrams, tables, and graphs, so that students can represent and emphasize broader meanings.

Research conducted by Pradana [17] on multi-representation test instruments showed a positive response as seen from the results of the scores obtained by students. Based on this, in evaluating the development of instruments to measure multi-representation skills, it is necessary to continue to develop them in physics materials. One of them is in the material on momentum and impulse. This material is very closely related to everyday life, so the basic concepts in this material need to be studied and understood in studying physics. According to Ngurahrai, Farmaryanti & Nurhidayati [18] momentum and impulse are one of the materials in physics that are quite complex. Based on this, the multi-representation assessment instrument is suitable to be developed in the material on momentum and impulse with cognitive levels ranging from C1 to C6. Therefore, students' multi-representation abilities in solving physics problems need to be developed more widely, one of which is to study and understand this material.

Based on the results of interviews with physics teachers at SMA Negeri 1 Semarang, it was found that the use of assessment instruments in the form of representation questions only measures several multi-representation abilities, such as those often used, namely graphic representation, tables, and equations. This is less than optimal because the ability of other representation skills has not been measured optimally. Another thing is that the use of cellphones when conducting assessments is also a cause of students being less skilled in interpreting physics problems. Another cause of the lack of student multi-representation is that the physics assessment instruments used so far do not pay enough attention to multi-representation skills.

Based on the interviews that have been conducted, teachers need a representation assessment instrument to measure students' multi-representation skills, with the materials used being momentum and impulse. Based on the background that has been described. The development research that will be conducted is the development of a

physics assessment instrument to measure the multi-representation skills of high school students on momentum and impulse materials.

B. Method

Research Design

This research is a development research (R&D). This research is usually called a bridge between (basic research) basic research and (applied research) applied research [19]. According to Sugiyono [20], Research and Development (R&D) is a method in research, with output to produce a product which will then be tested for the effectiveness of a particular product. The research to be conducted is to develop a physics assessment instrument. The development of this instrument uses a 4-D model research design. This model consists of four stages of development, namely, define, design, develop, and disseminate [21]. This study only uses three stages of the 4-D design, namely up to the develop stage. This is because at this stage it has been possible to obtain validity, reliability, differentiating power, and level of difficulty so that the instrument developed can be used to measure students' multi-representation skills. Briefly, the stages used in developing this research can be seen in the Figure 1 below.

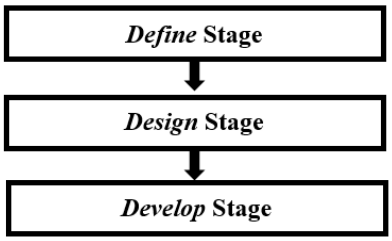

Figure 1. Research Development Steps

Content Validity Test

Content validity testing can be done using an instrument grid or matrix in instrument development [19]. An instrument is said to be valid if the instrument can measure what will be measured. Later, it will be validated by three validators as experts in the material field who conduct a review of the questions, including aspects of material feasibility, question construction, and the language used.

Reliability Test

Reliability testing in this study uses internal consistency testing. Testing is done by trying out the developed instrument once. Then analyzed with a certain technique whose analysis results are used to determine the reliability of the instrument. The technique used is the Kuder Richardson technique which is often abbreviated as KR-20 [20].

$$r = \left(\frac{k}{(k-1)}\right)\left(1 - \frac{\sum p(1-p)}{St^2}\right) \quad (1)$$

$$st^2 = \frac{x^2}{n} \quad (2)$$

With reliability criteria in Table 1

Table 1. Reliability Criteria

Reliability Index	Reliability Criteria
0,0 ≤ r ≤ 0,2	Very low
0,2 < r ≤ 0,4	Low
0,4 < r ≤ 0,6	Medium
0,6 < r ≤ 0,8	High
0,8 < r ≤ 1,00	Very high

Differentiating Power

Differentiating power is the ability of a question to distinguish between students who have and have not mastered the material [22].

$$DP = \frac{BA-BB}{\frac{1}{2}N} \quad (3)$$

With differentiating power criteria in Table 2

Table 2. Classification of Differentiating Power of Questions

Interval of differentiating	Power Level of Questions
0,40 < DP ≤ 1,00	Very good
0,30 < DP ≤ 0,40	Good
0,20 < DP ≤ 0,30	Enough
0,00 ≤ DP ≤ 0,20	Bad

Difficulty Level

The level of difficulty is the opportunity for students to answer a question correctly [22]. A good question is a question that is not too easy and not too difficult [23].

$$TK = \frac{B}{Js} \quad (4)$$

With difficulty level criteria in Table 3

Table 3. Classification of the Level of Difficulty of Test Items

Difficulty Level	Category
0,00 < TK ≤ 0,30	Difficult
0,30 < TK ≤ 0,70	Medium
0,70 ≤ TK ≤ 1,00	Easy

Analysis of Students' Multirepresentational Skills

Analysis of multirepresentational skills is done by using the scores obtained from students' test results. The data from the test results are then analyzed to determine the category of students' multirepresentation skill levels.

$$\text{Score} = \frac{\text{Total Score of Students}}{\text{Total Score}} \times 100\% \quad (5)$$

With multirepresentation skills level in Table 4.

Table 4. Multirepresentation Skill Level Category

Student Score	Multirepresentation Skill Level
80 < Score ≤ 100	Very Good
60 < Score ≤ 80	Good
40 < Score ≤ 60	Enough
20 < Score ≤ 40	Bad
0 ≤ Score ≤ 20	Very Bad

C. Result and Discussion

The initial product of the instrument development is a test question consisting of 40 questions, in the form of multiple-choice reasoning with each question and reason having five answer choices. The test questions are made based on matrices of various types of multirepresentation. The test instrument development product has several components as follows Multirepresentation Test Instrument Matrix, Multirepresentation Test Instrument Grid, Multirepresentation Test Questions, Answer Key, Multirepresentation Instrument Scoring Guidelines, and Validation of Multirepresentation Test Instrument.

Product Trial Results

Product trials were conducted with small-scale tests conducted at SMA Negeri 1 Semarang. This small-scale test involved 33 students of grade XI-9 majoring in physics. Students worked on 40 questions with a duration of 3 JP. The results of this

product trial were used to determine the reliability of the questions, level of difficulty, and differentiating power on the multirepresentation instrument.

Question Reliability Test

The consistency of questions on the instrument can be determined by using the instrument reliability test. The analysis of the reliability test of the multirepresentation test instrument uses the KR-20 equation. The results of the analysis of the instrument reliability test obtained a value of r_11 = 0.78 which is in the high category and can be seen in Appendix 30.

Question Difficulty Level Test

The grouping of questions into difficult, medium, and easy categories can be determined by testing the question difficulty level. A question can be said to be good if the question is not too difficult and not too easy [24]. This is because questions that are too easy make students tend not to think and questions that are too difficult make students give up easily and have difficulty in working on the question I Table 5.

Table 5. Analysis of Question Difficulty Level Test Results

Category	Question Number	Number of Questions
Difficult	10, 11, 12, 14, 16, 17, 19, 20, 21, 22, 24, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 39, 40	24
Medium	1, 2, 3, 4, 5, 6, 7, 8, 9, 13, 15, 18, 23, 25, 34, 38	16
Easy	-	0

Table 5 shows the percentage of question difficulty levels consisting of 40% of questions in the medium category and 60% of questions in the difficult category.

Test of Question Differentiating Power

The ability of question items to differentiate between students with high and low abilities is obtained by conducting a test of question differentiating power [24]. This multirepresentation test instrument has question differentiating power with good, sufficient, and poor criteria. Questions that have poor differentiating power must be discarded and cannot be used in large-scale tests, while questions that have good and sufficient differentiating power can be used in large-scale tests and are not discarded. Questions with a poor category cannot be used to differentiate between students with high abilities and students with low abilities Table 6.

Table 6. Analysis of the Results of the Test of Differential Power of Questions

Category	Question Number	Number of Questions
Bad	9, 10, 11, 18, 19, 21, 24, 28, 29, 30, 31, 33, 35, 38, 39	15
Enough	1, 3, 4, 7, 8, 12, 13, 16, 17, 20, 22, 23, 25, 26, 27, 32, 34, 37, 40	19
Good	2, 5, 6, 14, 15, 36	6
Very Good	-	-

Product Revision

After conducting a small-scale trial, the multirepresentation test instrument was revised first before being used in a large-scale test. The revision was based on the results of the small-scale test which included validity, reliability, level of difficulty, and question differentiating. Based on the results of the small-scale test, it was found that out of 40 questions, 15 were not feasible, meaning they had to be discarded, and 25 were feasible. A total of 20 questions were used in the large-scale test. This was because out of 25 questions that were declared feasible, 20 of them had met the various representations used.

Final Product Review

The implementation of the large-scale test at SMA Negeri 1 Semarang involved 66 students in grade XI consisting of 33 students in grade XI-8 and 33 students in grade XI-11. The instrument used in the large-scale test was the instrument of the results of the analysis that had been carried out in the small-scale test. Students worked on 20 questions in the large-scale test. The results of the analysis showed that students' multirepresentation skills in all representations had an average value of 76.89%, which is in the good category in Table 7.

Table 7 Summary of Multirepresentation Skills Results

Category	Frequency (Students)	Percentage (%)
Very Good	30	45,45
Good	31	46,97
Enough	4	6,06
Bad	1	1,52
Very Bad	-	-

The product developed is a multiple-choice test with reasoning to measure certain types of representation and translation of representation. The material tested is momentum and impulse material that refers to the independent curriculum. The instrument developed uses various types of representations ranging from verbal representations, images, graphs, mathematical equations, tables, and diagrams. The instrument is also developed based on cases in everyday life.

The results of students' answers in the large-scale test were analyzed to determine students' multirepresentation skills. Analysis of students' multirepresentation skills was carried out on each type of representation and translation of representation. The analysis aims to determine the extent of students' representations based on the representation matrix that has been developed Table 8.

Table 8. Analysis of Students' Multirepresentation Ability

Type of Representation	Percentage of Score for Each Representation (%)	Skill Category
Verbal	72,7	Good
Picture	80,3	Very Good
Mathematical Equation	73,3	Good
Table	82,55	Very Good
Graph	85,6	Very Good
Diagram	72,7	Good
Graph to Mathematical Equation	81,8	Very Good
Picture to Mathematical Equation	74,2	Good
Verbal to Mathematical Equation	59,1	Enough
Picture to Verbal	83,3	Very Good
Table to Graph	87,9	Very Good
Table to Mathematical Equation	71,2	Good

Based on the analysis that has been done, the students' multirepresentation skills for each type of representation have an average value of 50.75% on the momentum and impulse material. The final result of the instrument development in this study is a test instrument to measure the multirepresentation skills of students of SMA Negeri 1 Semarang class XI majoring in physics on the momentum and impulse material. The instrument developed is in the form of multiple-choice reasoned questions. A similar instrument was developed by [25] who developed an objective multiple-choice reasoned test assessment instrument to measure mastery of linear motion teaching materials and science process skills.

The feasibility of multirepresentation test instruments can be seen through the results of validity, reliability, level of difficulty, and differentiating power. Content validity shows that out of 40 questions, they are declared valid overall. These results were obtained because each question item validated by an expert was in accordance with the assessment aspects on the validation sheet indicators. Reliability, differentiating power, and level of difficulty were obtained from small-scale trials. The differentiating power of the 40 questions was obtained, 15 questions had poor differentiating power, 19 questions were sufficient, and 6 questions were good. These results were obtained because the test questions were made with cognitive levels ranging from C1 to C6, so that the final result was 25 questions that were feasible and could be used. The reliability of the multirepresentation test instrument obtained a value of r11 = 0.78 which is in the high category so that the test items can be said to be reliable. These results were obtained from the Kuder Richardson equation (KR-20). This is in accordance with Maulana [26], he stated that an assessment instrument

cannot be used directly, its validity must be tested so that the instrument is said to be feasible and can be used in the field. Based on the results obtained, it can be concluded that the multirepresentation test instrument is feasible to be used to measure the multirepresentation skills of class XI physics students at SMA Negeri 1 Semarang.

Multirepresentation skills analysis based on student scores obtained an average percentage of all representations of 76.89% in the good category. These results were obtained because of the multirepresentation approach which mainly emphasizes various representations ranging from verbal, images, mathematical equations, diagrams, tables, and graphs so that they can help during the evaluation process in learning [10]. Based on this percentage, it was obtained that 30 students had multirepresentation skills in the very good category, 31 students were good, 4 students were sufficient, and 1 student was in the poor category.

These results were obtained because students' understanding of the momentum and impulse material was quite good through the review carried out before working on the test questions, so that good test results were obtained, even so there were still students with poor multirepresentation skills. This happens because the factors of comprehension and learning motivation of each student are different, so that the review of the material carried out before working on the questions cannot be understood properly. This is because the review of the material is done briefly with a short time before the test starts.

Based on the results obtained, multirepresentation skills in each type of representation and translation of representations obtained good results except for the translation of verbal representations into mathematical equations which received a percentage in the sufficient category. This happened because students still had difficulty expressing and analyzing the meaning of words in the questions to the meaning of mathematical equations in the answer options. Another factor that influences the results of multirepresentation skills in each type of representation is the use of illustrations of images, graphs, diagrams, and sentences in the questions that are appropriate, clear, and easy to understand so that students' multirepresentation skills get good results and can be measured widely. Ceuppens et al. [16] developed a multirepresentation test instrument in physics assessments that only represented graphic representations, tables, and mathematical equations so that in the study the students' multirepresentation skills were measured less widely. Based on this, it can be concluded that the final results of a broader multirepresentation assessment can produce better multirepresentation skills with appropriate representation assessments in learning, so that it can improve students' multirepresentation skills.

D. Conclusion

Based on the results of the analysis and discussion that have been obtained, it can be concluded. The instrument is declared feasible to measure the multirepresentation skills of students of SMA Negeri 1 Semarang class XI majoring in physics. This is proven by the question instrument which is declared valid by three validators who have cognitive levels C1, C2, C3, C4, C5, and C6. The multirepresentation test instrument that has been developed is declared reliable with a value of r11 = 0.78, which is in the high category. The instrument has been tested with a small-scale test and the level of difficulty of the questions consists of 40% of questions in the medium category, 60% of questions in the difficult category. Based on the results of the differentiating power of the questions obtained from 40 questions, 25 questions were declared feasible. The multirepresentation skills of students of SMA Negeri 1 Semarang class XI majoring in physics were measured using the multirepresentation test instrument, the overall results were in the very good category with a percentage of 44.45%, good 46.97%, sufficient 6.06%, and lacking 1.52%. This means that students' multirepresentation abilities are classified as good, seen from the level of difficulty of the questions and students' abilities in working on the questions. The overall average of students' multirepresentation skills is in the good category with a percentage of 76.89%.

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