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Development Of Test Instruments to Improve Students' Multirepresentational Ability

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Abstract: The aim of this research is to determine the feasibility of a physics test instrument to measure high school students' multiple representation abilities in rectilinear motion material and to determine the characteristics of respondents' multirepresentation abilities in rectilinear motion material. The development of this instrument was carried out using a modified development method of the Wilson, Oriondo, and Antonio. Students' multiple representation abilities were analyzed with the help of Quest which was then analyzed further using descriptive statistics. The results of this research are in the form of a test instrument to measure high school students' multi-representation abilities in rectilinear motion material consisting of 20 two-tier multiple choice questions. The items in the questions are valid, fit the PCM 1 PL model, have very good reliability with a score of 0.84, and have a good level of difficulty. The results of item analysis and analysis of students' abilities show that the instrument developed is effective in measuring high school students' multi-representational abilities in rectilinear motion material.

Keywords: linear motion material; multi-representation ability; two-tier multiple choice test instrument

Introduction

Multi-representation ability is one of the important abilities in learning science, especially physics. This ability is important because it has a major contribution in increasing the understanding of physics concepts (Nieminen et al., 2012; Van Heuvelen, 1991), is a key feature in scientific literacy (Nitz et al., 2014), and has a role in increasing problem-solving abilities (Bollen et al., 2017). In addition, the fact that natural phenomena in physics are usually explained in various forms of representation such as graphs, pictures or mathematical equations further supports the importance of multi-representational abilities in learning physics.

Even though multi-representational ability is very important in physics, learning in schools is currently not oriented towards improving students' multi-representational abilities. Several things indicate this situation, namely research by (Furqon & Muslim, 2019) which found that students' multi-representation abilities were still low at SMA Negeri 14 Bandung and research by (Kusumawati et al., 2019) which showed that participants' multi-representation abilities students on the islands of 2 Java, Sumatra, and Kalimantan are still dominated by mathematical representation abilities with an average score of 80% of the total score.

The low multi-representation ability of students in physics subjects can be caused by many factors. These factors include learning physics which tends to emphasize mathematical representations and lacks meaning in mathematical equations and visualization of other representations (Fatmaryanti & Sarwanto, 2015; Kusumawati et al., 2019) and lack of emphasis on learning concepts and multirepresentations in physics learning (Furqon & Muslim, 2019).

Seeing that students' multi-representation abilities are not maximized and are still concentrated on one of the representation abilities, many studies recommend learning that is able to increase students' multi-representation abilities effectively. Various lessons that have proven effective in increasing multi-representational abilities include learning by utilizing concrete and virtual models Stull & Hegarty (2016), professional learning based on multi-representation and conceptual understanding (Nichols, Ranasinghe et al., 2013), learning physics using the energy transfer model

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(ETM) approach (Kubsch & Hamerski, 2022), learning using descriptive-explanative mathematical models (Majidi, 2012), learning using online 3 learning modules (Hill et al., 2015), and learning using simulation (Nichols, Hanan et al., 2013).

Various efforts to improve multi-representational abilities through these learning activities certainly cannot run well without proper assessment of students' multi-representational abilities. The results of an appropriate assessment of students' multi-representational abilities in class can be used by educators as a reference in preparing appropriate learning designs to improve multi-representational abilities and other cognitive abilities that are closely related to students' multi-representational abilities. Therefore, physics assessment instruments are used to measure abilities. Multi-representation of students is an important part of efforts to improve the ability of multi-representation of students.

Several physics assessment instruments to measure students' multi-representational abilities have actually been developed quite a lot. However, the developed instrument still measures some representational abilities and has not been able to measure more representational abilities. This of course causes the instrument to only be able to identify multi-representational abilities in several forms of representation and miss identification in more complete forms of representation.

Several instruments on kinematics materials developed by (Lichtenberger et al., 2017; Putri et al., 2020), only measure representational abilities in at most four forms of representation. Other studies such as the research of developed an instrument to identify the ability to translate representations between graph-mathematical equation representations and vice versa. (Ceuppens et al., 2018; Klein et al., 2017) developed a multi-representational instrument that focuses on the three forms of representation and the translation of representations between the three forms of representation.

Based on the fact that existing instruments for measuring multi-representational abilities do not measure more representational abilities, a physics assessment instrument that is capable of measuring multi-representational abilities in the form of more representations needs to be developed. With more forms of representation being measured, it is hoped that information on students' multi-representation abilities in physics subjects can be obtained in a more complete manner so that educators can provide more comprehensive treatment in improving students' multi-representation abilities.

The study of physics, especially regarding problems of rectilinear motion, is wrong a problem that can be represented in quite many forms representations such as in graphical, pictorial, formal, verbal and numerical forms. Apart from that, this material is also one of the materials in physics whose concepts the concept is widely used as a basis for understanding subsequent material so the multi-representation capability in this concept needs to be matured. Therefore, the development of ability measurement instruments multi-representation of students with more aspects of representation measured for rectilinear motion material is very necessary.

Method

This research is a development research. Instrument development was carried out using a modified development model from the Wilson development model, the Oriondo Development Model, and the Antonio Development Model which were adopted based on research by Istiyono et al. (2014), in this modified development model, the development stage is generally divided into three, namely test design, test trials, and test assembly.

The test design stage includes: determining the test objectives, determining the competencies being tested, determining the material being tested, preparing the test grid, writing items based on the principles of HOT Test development, validation of test items, item improvement and test assembly, and preparation of scoring guidelines. The test trial stage includes: determining the test subject (SMA), carrying out the trial, and analyzing the trial result data. The final stage in test development is test assembly. The stages of test development are presented in Figure 1.

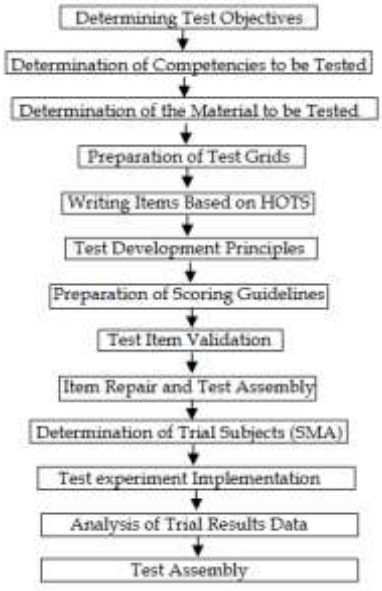

Figure 1. The test design stage

Result and Discussion

The validity of the items can be identified by the amount of Infit MNSQ from the Quest program output. The instrument is said to be empirically valid if the question of fit with the model is characterized by an MNSQ infit value in the range $0.77 \leq infit\ MNSQ \leq 1.30$. The following table summarizes the results of item and case estimation for instruments using the Quest program.

Table 1. Summary of Item Estimation Results by the Quest Program

Aspect	Item estimation	Case estimation
Average value	0.00	1.20
Standard definition of average value	0.76	0.53
Standard definition of average value (adaptability)	0.70	0.36
Realibility	0.84	0.44
Infinit MNSQ	1.00	0.99
Standard definition of average value infinit MNSQ	0.07	0.29
Infinit t	0.19	0.01
Standar definition infinit t	0.97	0.84

Based on the results of item estimation for the MNSQ infit value, it can be seen that the MNSQ infit value is 1.00 ± 0.07 which indicates that the test instrument is empirically valid. This was confirmed based on the distribution of the MNSQ infit values which showed that all items were empirically valid and had an MNSQ infit between 0.88 and 1.14. The following is a map of the distribution of MNSQ infit values for each item.

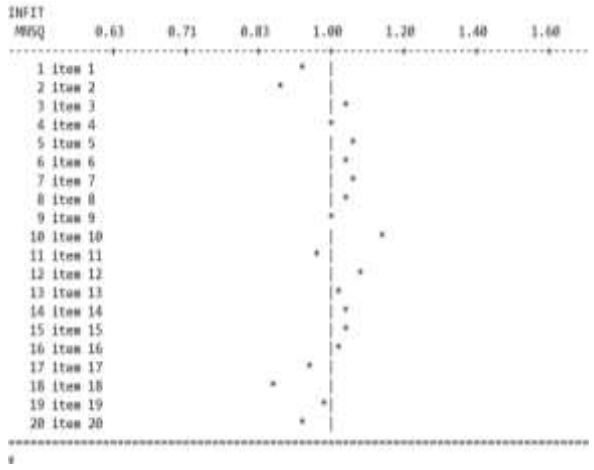

Figure 2. Map of the distribution of MNSQ infit values for each item.

The reliability of the test can be determined by looking at the reliability estimate value for the items in the Quest program output file. Based on the results of the Quest analysis, the reliability value of the test that was successfully developed was at a value of 0.84. This shows that the test developed is reliable to be used as a test instrument. The test instrument is said to be reliable based on the reliability criteria by Kaplan (2018), with a minimum reliability coefficient range of 0.70 – 0.80. With reference to the opinion of Arikunto (2012), the developed instrument has very good reliability criteria because it is included in the score range for very good criteria, namely 0.8-1.00.

Test instruments that were successfully developed generally had a level of difficulty with an average value of 0.00 ± 0.76. This shows that the test generally has a good item difficulty level because it is in the range of good difficulty level criteria according to Hambleton et al. (1991), namely in the range of values -2 to 2. The difficulty level value for each item along with the interpretation of the difficulty level value is presented in table 2.

Based on table 2 it can be seen that the most difficult items are in the difficult category with a difficulty level value of 1.75, namely item 15, while the easiest items are in the easy category with an item difficulty level value of -1.13. Besides the good level of item difficulty, the distribution of item difficulty levels for this multi-representational test instrument is also mostly at moderate level of difficulty. In addition, easy and difficult items have the same number. The distribution of item difficulty levels can be seen in Figure 3.

Table 2. Assess the difficulty level of each item

Difficulty level	Explanation
-1.13	Easy
-0.91	Easy
-0.05	Medium
-0.38	Medium
0.26	Medium
-0.29	Medium
0.78	Hard
-0.8	Easy
0.74	Hard
0.25	Medium
0.2	Medium
-0.13	Medium
0.67	Hard
0.38	Medium
1.75	Hard
1.04	Hard
-0.09	Medium
-0.5	Medium
-1.09	Easy
-0.71	Easy

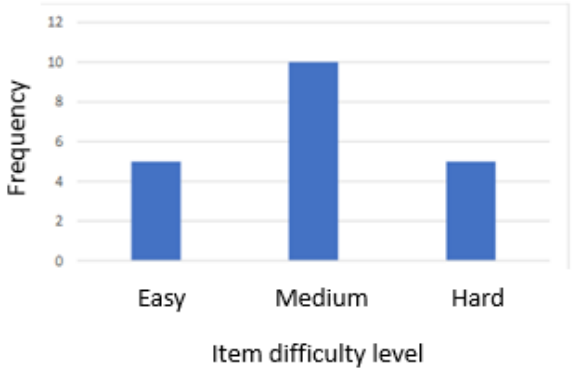

Figure 3. Frequency distribution graph for item difficulty levels

Based on the description above, it can be observed that the instrument items are valid based on expert judgment and are also valid after being empirically proven. This shows that the developed instrument is valid. In addition, this instrument also has very good reliability and a good level of item difficulty. Taking into account that the multi-representational test instrument developed is valid, reliable, and has a level of 0 2 4 6 8 10 12 Easy Moderate Difficult Frequency Good level of difficulty item 62, then the instrument can be said to be suitable for measuring students' abilities.

Conclusion

The test instrument developed consisted of 20 questions in the form of two-tier multiple choice to measure multi-representational ability consisting of 15 items to measure aspects of students' representational abilities and 5 items to measure aspects of students' representational translation abilities. The test instrument developed in this study was considered appropriate for measuring high school students' multi-representational abilities in straight motion material based on the criteria of content validity, goodness of fit, test reliability, and item difficulty level. Most of the students who were respondents had the ability multirepresentation tends to be low both in terms of ability representation in various forms of representation and aspects of ability representational translation.

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Author Contribution

Conceptualization, F.A and E.I methodology, F.A and E.I; formal analysis, F.A; investigation, F.A; resources, F.A and E.I; data curation, F.A; writing—original draft preparation, F.A writing—review and editing, F.A.: visualization, F.A. All authors have read and agreed to the published version of the manuscript.

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Conflict Of Interest

The authors declare no conflict of interest.

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