

Dissemination of symbolic representation ability in high school physics subjects

M F T Nirmala¹, Supahar¹, S Sundari²

¹Physics Education, Universitas Negeri Yogyakarta, Sleman, Indonesia

¹Physics Education, SMA Negeri 1 Banguntapan, Bantul, Indonesia

Corresponding author: maria0020pasca.2018@student.uny.ac.id

Abstract. The purpose of this study is to look at the validity and reliability of the symbolic representation ability test instrument, as well as the spread of the symbolic representation abilities of high school students. The research method used is the development of test instruments. Nine items were developed with 5 alternative answers. The physics material being tested is Newton's Law of Motion. The results of the validation analysis showed that the instrument developed was valid, with Aiken's V value greater than 0.88. Also, the instrument developed was compatible with the Rasch model. The characteristics of the difficulty index test items are in the good category. The reliability of the instrument is 0.70, and is feasible to be used to measure the symbolic representation ability of students with a minimum ability of -1.25. The trial was conducted on 62 students of SMA Negeri 1 Banguntapan. The average measurement result of the symbolic representation ability of students in high school physics subjects is -0.001 ± 0.144 . It can be concluded that the symbolic representation ability of students of SMA Negeri 1 Banguntapan in physics is in the medium category.

Keywords: *dissemination, symbolic representation ability*

1. Introduction

Assessment is an important part of the learning process. Regulation of the Ministry of Education and Culture No. 23 of 2016 on assessment standards explained that the assessment is a process of collecting and processing information to measure the achievement of learning outcomes of students. Assessment is not only limited to providing several test questions, then shows the true and false scores of students, but provides information about the achievement patterns of mastery ability of students concerned [1]. Assessment is needed in terms of monitoring the process, progress, and improvement of student learning outcomes on an ongoing basis. Information in the form of assessment results can help teachers and students in planning follow-up activities so that ultimately they will improve learning outcomes. Therefore, in general, the assessment refers to two types of activities that must be carried out, namely the activity of gathering information and the utilization of information that has been collected for the benefit of increasing the ability of the individual being assessed or the institution where the assessment is conducted.

Physics as a branch of science that provides learning experiences to understand concepts and practice the ability of inquiry related to natural phenomena [2]. The success of the learning process can be seen from how far the development of students' understanding of the concept. Abstract physical concepts, expressed in various forms of representation to explain certain phenomena [3]. Understanding of these concepts depends on the ability of students to understand the form of representation used.



Types of representations include visual, verbal and mathematical representations. This type of representation requires each ability to solve problems [4]. Problems represented visually (pictures, graphs, diagrams) require the ability of visual representation in solving problems. Likewise for the ability of other representations. Various forms of representation help students in understanding a concept [5]. This is supported by the research of Liliarti & Kuswanto [6], showing that the ability of diagrammatic and argumentative representation can improve the understanding of Newton's Law concepts in students.

According to De Cock [7], the skills needed in the use of representation are fluency and flexibility in solving problems. Solving problems in physics, some use various equations (symbols), use simultaneous solutions, and some also ask to manipulate general equations. According to Torigoe & Gladding [8], this transition is troublesome for students because of confusion when equations are combined. Symbolic questions tend to be more difficult because symbols are used in physics not only as the process of solving certain quantities but also as expressions of the relationships between quantities.

Physics is part of the science family. The ability to represent scientific phenomena is the key to solving problems [9]. The results showed that the inability of students to represent scientific phenomena turned out to be a barrier to solving scientific problems related to macroscopic and symbolic phenomena [10], [11]. Each symbol form links a simple conceptual scheme of arrangement of symbols in a physical equation. Learners must understand the concepts of several physical situations and express that understanding into an equation. Students must also be able to see that the equation formed is a concept and not understand it as a specific description of the physical system. It can be concluded that the understanding of the concept of physics influences the ability of the symbolic representation of students

2. Research method

This study uses a quantitative approach. The research subjects were high school students. The sample of this study was 62 students from SMA Negeri 1 Banguntapan. The purpose of this study is to determine the validity and the reliability of the symbolic representation ability test instrument, as well as the spread of the symbolic representation abilities of high school students. The instrument development procedure refers to the model developed by Mardapi [12]. The stages of instrument development can be seen in Figure 1. Indicators of mastery of symbolic representations in this study can be seen in table 1.

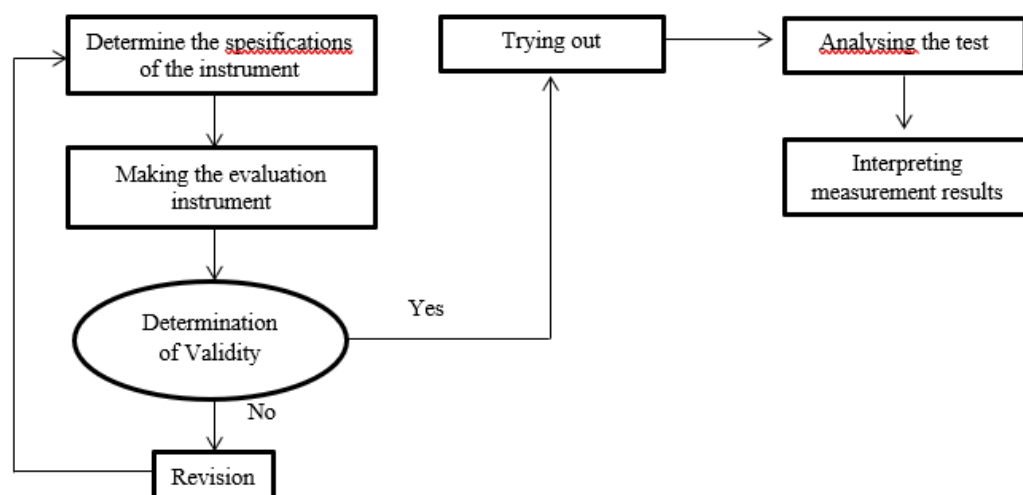


Figure 1. Development procedure.

Table 1. Indicator of symbolic representation.

Aspect	Indicator
<ul style="list-style-type: none"> Collecting data 	Differentiating entities
<ul style="list-style-type: none"> Connecting several variables 	Show the relationship between the variables presented
<ul style="list-style-type: none"> Interpret data 	<ul style="list-style-type: none"> Present information obtained from a representations in the form of symbolic representation Present information obtained from symbolic representations to other forms of representation
<ul style="list-style-type: none"> Give a conclusion 	Decide to use the right representation in solving problems

The instrument for evaluating the symbolic representation ability of students consists of 9 multiple choice test items, with 5 alternative answers. The validity of the contents of the assessment instruments was obtained through expert judgment involving four experts. Results assessing expert judgement was analyzed using the Aiken V formula. The index V value ranges from 0 - 1. The Aiken's coefficient V boundary condition for 5 rating scales and 4 rater is 0.88 with a probability of 0.024 [13]. The Aiken V formula is formulated as follows [13]-[15].

$$V = \frac{\sum s}{[n(n-1)]} \quad (1)$$

Description, s is $r - lo$, n is number of panels of assessors, c is highest validity assessment, lo is lowest validity assessment, r is the number given by an assessor.

Trial Instrument assessment was conducted on students of class XI MIPA 2 and XI MIPA 4 in SMA Negeri 1 Banguntapan. Learning material uses the topic of Newton's Laws of motion. Empirical validity is obtained through the analysis of item responses to test results. Evidence of empirical evidence can be determined by using the Classical Test Theory (CTT) or Item Response Theory (IRT) [16]. The determination of the fit of the scoring model by the Rasch model is carried out using the Quest program. Item is fitted with the Rasch model if the MNSQ INFIT value is in the range of 0.77 to 1.30 [17].

Reliability is a coefficient of the consistency of the measurement results of a test. Test reliability estimates were analyzed using classical test tokens and modern test theory. An instrument is said to have good reliability if the reliability coefficient of the instrument is ≥ 0.70 [12]. The higher the reliability coefficient of a test, then the possibility of errors that will occur will be smaller if you will make a decision based on the scores obtained in the test [18] Estimation of reliability tests in IRT is determined through estimation curve Standard Error Measurement (SEM) and total function information (TFI) . The graph of the intersection between the information function and the SEM, states the level of reliability of an assessment instrument. The higher the value of the test item information function, the more reliable the test [19]. Characteristics of the difficulty index (b) criteria of a test item are categorized as very difficult if $b > +2$ and categorized as very easy if $b < -2$ [20] According to Subali [21], the higher the value of the item difficulty level, the more item items are judged to be more difficult. Conversely, the lower the value of the difficulty level of an item, the easier the item concerned.

Results estimate the ability of representation symbolic is presented in the form of a frequency distribution of abilities in the logit scale. Categories of the measurement results of symbolic representation capabilities are stated based on the following criteria [22] [23].

Table 2. Converting quantitative value into qualitative.

Ability Interval	Level
$M_i + 1.5SB_i < \theta$	Very high
$M_i + 0.5SB_i < \theta \leq M_i + 1.5SB_i$	High
$M_i - 0.5SB_i < \theta \leq M_i + 1.5SB_i$	Medium
$M_i - 0.5SB_i < \theta \leq M_i - 1.5SB_i$	Low
$\theta < M_i - 1.5SB_i$	Very Low

3. Result and Discussion

The results of the analysis of the content validity using V Aiken for the instruments developed can be seen in table 3. Each concept measured had an Aiken's score above 0.88. Based on the Aiken's coefficient V boundary conditions for 5 rating scales and 4 raters [13], the instrument for evaluating the symbol representation ability is valid so that it is feasible to be used in this study.

Table 3. Aiken's V score for 9 item symbolic representation ability tests.

No	Concept	V Aiken
1	Force	0.90
2	Newton's First Law	1
3	Newton's Second Law	1
4	Normal Force	1
5	Two kind of mass	1
6	Friction on the plane	0.90
7	Friction on the incline plane	0.90
8	Acceleration on a flat plane	0.90
9	Acceleration on the incline plane	1

Test items that have been proven valid then tested. The number of students involved in the trial was 62 students, at SMAN 1 Banguntapan, Bantul. Students' responses to 9 developed test items were analyzed using Item Response Theory (IRT). The results of the test suitability analysis based on empirical data can be seen in table 4.

Table 4. Fit Statistics test parameters at opportunity level 0.50.

No	Aspect	Item Estimation	Testi Estimation
1	Average value and standart deviation	0.00 ± 1.19	-0.27 ± 0.73
2	Adjusted average and standard deviation	1.15	0.00
3	The mean value and standard deviation of INFIT MNSQ	0.98 ± 0.10	1.00 ± 0.52
4	The mean value and the MNSQ OUTFIT standard deviation	1.11 ± 0.51	1.11 ± 1.00
5	Reliability	0.70	
6	Average Difficulty	0.00 ± 0.48	

The dichotomous data with 5 alternatives were analyzed according to Rach's model. INFIT MNSQ analysis results from 9 test items, ranging in the range of 0.77 to 1.30. The MNSQ INFIT parameter shows that the instrument for assessing the ability of the symbolic representation of high school physics subjects meets the criteria of fit statistics according to the Rasch model. Therefore, the test item's symbol representation capability is valid. This is consistent with Supahar's research [24], stating that an item is

declared valid if it has INFIT MNSQ values in the range of 0.77 to 1.30. The results of a complete analysis of the validity of it can be seen in figure 2.

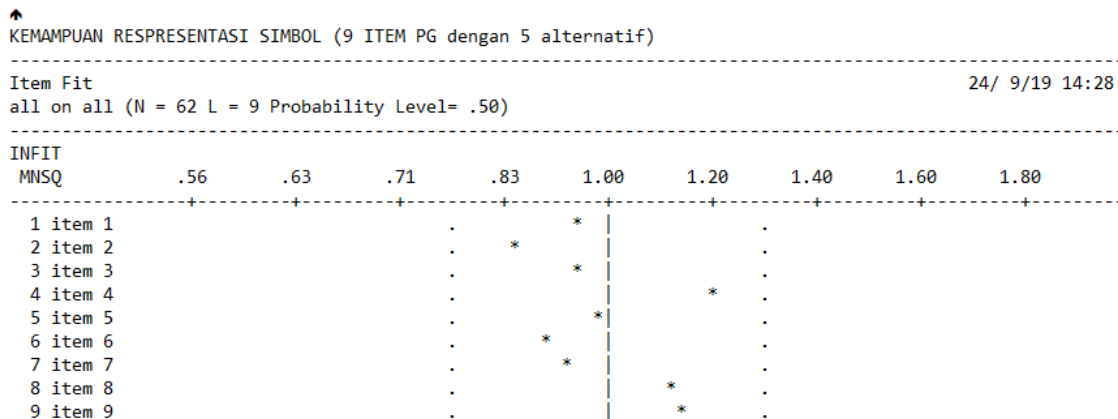


Figure 2. Item compatibility map with rasch model.

Characteristics of the test items have a difficulty index between the value of -0.71 (item 6) with easy categories up to 0.64 (item 5) with medium categories. Difficulty index averaged 0.00 ± 0.48 , with the medium category. Illustration of the comparison of the difficulty level of each item is presented in Figure 3. Index of difficulty instrument symbol representation capability ratings were in the range -0.64 until 0.64. Therefore, this instrument is classified as good because it meets the criteria. Test items with a difficulty index of -2.0 are categorized as very easy items, whereas a difficulty index of +2.0 is categorized as very difficult [20].

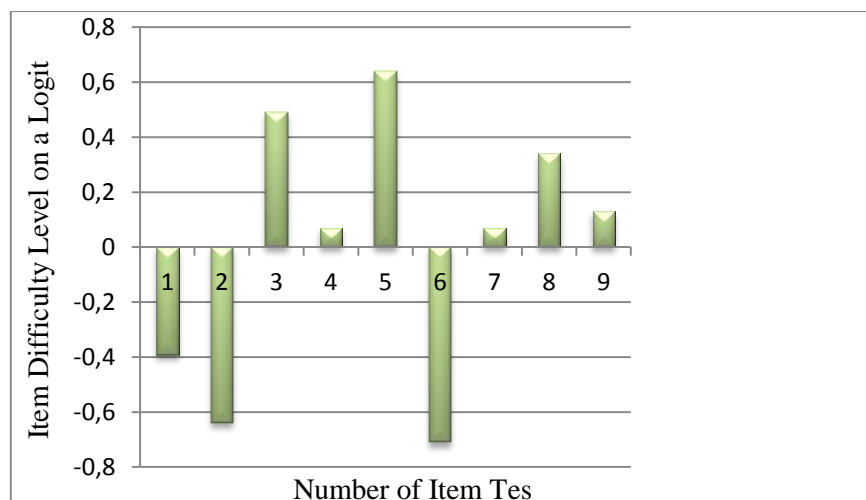


Figure 3. Difficulty level for each item test symbolic representation ability.

The reliability of the instrument measuring the ability to represent symbols included in either category, amounting to 0.70. Based on the results of the analysis of the items also obtained a relationship curve between the ability with the Total Information Function (TIF). The reliability of the test instrument according to IRT can be known through the Total Information Curve (TIC) graph and the Standard Error of Measurement (SEM). Figure 4 shows the curve of the Total Information Function and the Standard Error of Measurement instrument for evaluating the symbol representation capabilities of Newton's laws in high school physics subjects. Based on these curves it is known that the instrument of the symbolic representation ability is more precisely tested on respondents with a minimum ability of -1.25. Because this instrument can provide high information about the ability of the symbolic representation with a low measurement error rate when applied to respondents with a minimum ability of -1.25.

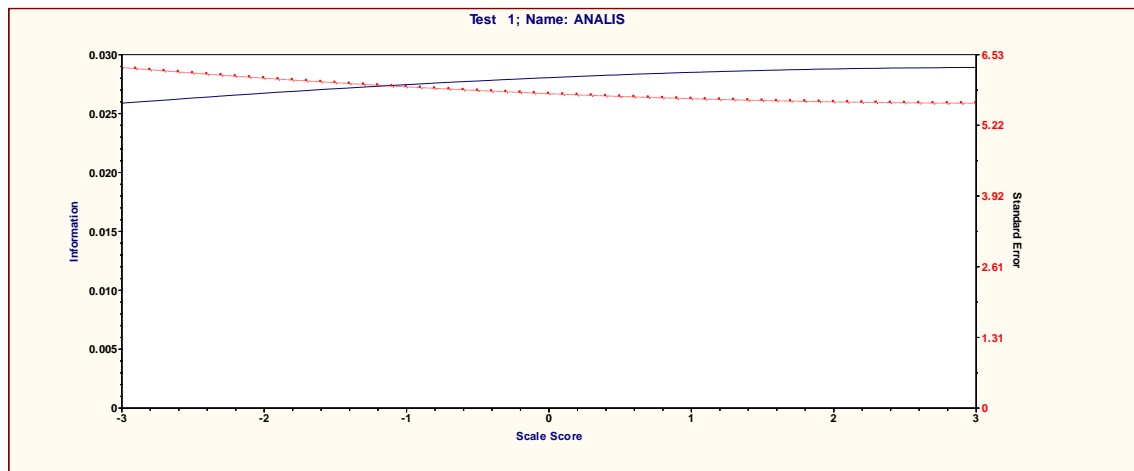


Figure 4. TIF Curve and SEM test instrument for the representation of symbols of high school Physics subjects

The ability of students can be known from the Parscale program output, namely files in PH3 and SCO formats. The ability to represent symbols of students is presented in the ability column on a logit scale. The results of measuring the symbol representation ability of 62 students resulted in a distribution of scores between -3 to 3 on a logit scale between -4 to +4.



Figure 5. Graphic distribution of students' symbolic representation ability.

Table 5. Level of symbolic representation ability and frequency of students.

Ability Interval	Level	Number of Students	Percentage
$\theta \geq +2$	Very high	1	1.6 %
$2.0 > \theta \geq +1.0$	High	17	27.4 %
$+1.0 > \theta \geq -1.0$	Medium	35	56.5 %
$-1.0 > \theta \geq -2.0$	Low	4	6.5 %
$\theta < -2.0$	Very Low	5	8.06 %

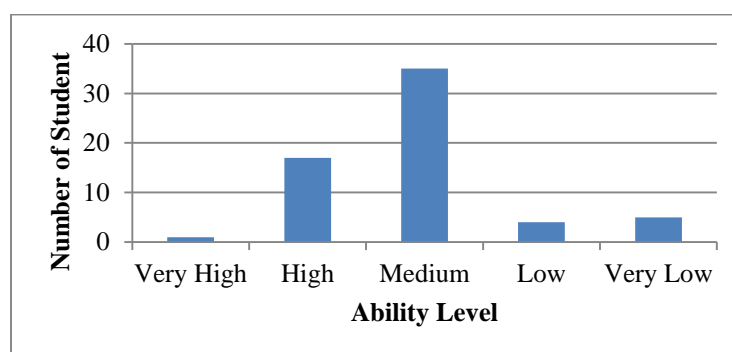


Figure 6. Graphic level of students' symbolic representation ability.

The distribution of the symbol representation ability of students can be seen in figure 5. The average measurement results of the symbol representation ability of students in high school physics subjects is 0.001 ± 0.144 . Based on the average score of the symbolic representation ability of students of grade XI MIPA of SMA Negeri 1 Banguntapan, it is known that the students have medium symbolic representation ability. Table 5 and Figure 6 show the frequency of students with a moderate ability level of 35 people. The percentage is 56.5 %. This amount is the most when compared with the frequency of students at other ability levels. This is because students are not able to connect symbolic representations with concepts so students are not able to solve the problems presented [25], [26]. Students who have a high understanding of the concept will be able to apply this knowledge to solve new problems [27]. Based on the results of this study indicate that the ability of symbolic representation in physics subjects of SMA Negeri 1 Banguntapan students still needs to be improved.

4. Conclusions

Based on these results we can conclude representation abilities test instrument symbolic high school learners with aspects of the assessment includes a symbolic representation capability. The assessment format uses multiple-choice tests with five alternative answers, consisting of nine test items. The validity of the test instruments according to expert judgement is declared valid and is appropriate to use and had obtained empirical evidence of fit with the Rasch model. All items on the test instrument represent the ability of symbols in good criteria. Symbolic representation ability test instrument can be used to measure the symbolic representation ability of students according to Rasch Model based on dichotomous data Based on the average score of the symbolic representational ability of students in grade XI MIPA of SMA Negeri 1 Banguntapan, it is known that the students have moderate symbolic representation ability.

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