Development of Assessments to Measure Students' Science Literacy Ability: Rasch Modeling Analysis

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Abstract - *Science literacy is a demand for education in the 21st century. The ability of science literacy in Indonesia is relatively low because the questions used are not based on scientific literacy. This research aims to produce assessment products on class XI straight motion kinematics materials that are suitable for use, then find out the responses of teachers and students, and find out the science literacy ability of students. The method in this research is Research and development (R&D) using the Borg & Gall development model to the eighth stage and data analysis on validity, reliability, level of difficulty and differentiating power tests using Rasch modeling.. The results obtained in this study are: (1) Product feasibility results based on material experts by 78% and declared feasible, then on media experts by 87.49% and declared possible. Then, the results of the validity of question items are displayed as suitable for use with a total of 20 valid questions, item reliability 0.90 (excellent). (2) The teacher's response result of 93.5% is excellent. Then, the response of students of 88.13% was excellent. (3) The lowest science literacy ability of students is in science as a way to conduct investigations, which is 34.50%, and the highest in science as a stem of science at 72.50%. So it can be concluded that the assessment product developed is suitable for use and the lowest scientific literacy ability results are in the aspect of science as a way to conduct investigations.*

Keywords*: Assessment; Science Literacy; Rasch Model*

INTRODUCTION

Along with the times, technological advances are currently experiencing such rapid development. This has an impact on various aspects of life, including the world of education. Education is essential in forming competent people to build a developed nation (Kerwin, 2015). In preparing quality and qualified human resources, education is vital in supporting national development. In preparing quality and competent human resources, education is essential in helping national development, following the ideals and objectives of educating the nation's life as stated in the preamble of the 1945 Constitution's fourth paragraph. Education is also the right and obligation of all Indonesian citizens (Depdiknas, 2003). A good curriculum is needed (Suwandi, 2020). The curriculum is a reference for educators in implementing the teaching and learning process.

The independent learning curriculum is a curriculum that gives freedom to students to learn and seek their talents (Muliaman et al., 2022). Through a separate curriculum, students are required to have good competence and, think logically, critically, creatively, and be able to collaborate well (Yuliati, 2017). The concept of an independent learning curriculum also carries literacy skills as one of the assessment components. In the 21st century, several types of literacy have developed in education, including science literacy (Putri, 2020).

The OECD states that scientific literacy refers to scientific knowledge and skills that enable a person to gain new knowledge, be able to explain scientific events, make decisions based on reality, know the characteristics of science, know how science and technology shape nature. , and cultural environment, as well as a

willingness to participate and be interested in science-related issues (OECD, 2018). According to Marhami et al. (2020), Scientific literacy is a person's ability to know science by communicating science and writing verbally; in other words, a scientifically literate person can make decisions based on scientific considerations and have high concern for themselves and the environment. Education in Indonesia, especially in the field of science, is still of low quality compared to other developing countries. The weakness of science education in Indonesia is shown by the low achievement of science literacy levels in PISA. From the results of the PISA survey in 2018, the ability of students in science literacy in Indonesia shows that the value of student literacy ability is still below the ideal weight of 500, with a score of 389, and students' scientific literacy results in Indonesia are ranked 70th out of 78 participating countries studied (PISA, 2018).

According to Toharuddin (2011), Indonesia's low scientific literacy skills are caused by conventional learning and assessment processes, so students are not familiar with the ability to understand science literacy. According to Adawiyah & Wisudawati (2017), science literacy ability can be measured with science literacy-based test instruments through assessments to be tested. The science literacy questions developed refer to indicators of science literacy. Therefore, in the learning process, students are expected to build their capacity/ability and be actively involved in the surrounding environment and the wider community (Kemendikbud, 2020). An assessment needs to be done in the learning process to determine how students achieve learning objectives. Irvika et al. (2021) explained several problems in the learning assessment process; among them are the students' tendency to memorize subject matter, low reading interest, and lack of training in answering questions in the form of discourse and numeracy. In addition, assessment has not led to aspects of mastery of science literacy, resulting in low achievement of science literacy.

Based on the results of observations and interviews with teachers at SMA Negeri 1 Gandapura, scientific literacy tests on students have never been carried out. Then the questions used also do not include scientific literacy. The school has never developed questions/made questions based on scientific literacy. Therefore, one effort is needed to train students' scientific literacy skills, namely by developing assessments that are intended to measure students' scientific literacy abilities.

The development of a scientific literacy assessment according to (Marhami et al., 2020) contains 4 aspects of scientific literacy, namely the body of knowledge aspect, the way of investigating aspect, the way of thinking aspect, and the interaction of science, technology and society aspect. In line with this, research conducted by (Chasanah et al., 2022) with the aim of developing a scientific literacy assessment instrument was declared feasible for measuring students' scientific literacy abilities as proven by 20 questions being declared valid. Then the student's scientific literacy profile falls into the medium category. And research was conducted (Mardhiyyah et al., 2016) with the aim of developing assessment instruments to measure students' scientific literacy abilities. The results obtained are that the literacy assessment instrument developed is suitable for use. And the profile of students' scientific literacy abilities is in the low category. The highest scientific literacy ability is in the body of knowledge aspect and the lowest is in the interaction aspect of science, technology and society.

Based on the description above, an effort is needed to develop a scientific literacy assessment to train students in working on scientific literacy problems and measure their scientific literacy abilities.

RESEARCH METHODS

This study uses a type of development research (Research and Development) or known as R&D. With the Borg & Gall development model to the eighth stage, namely:

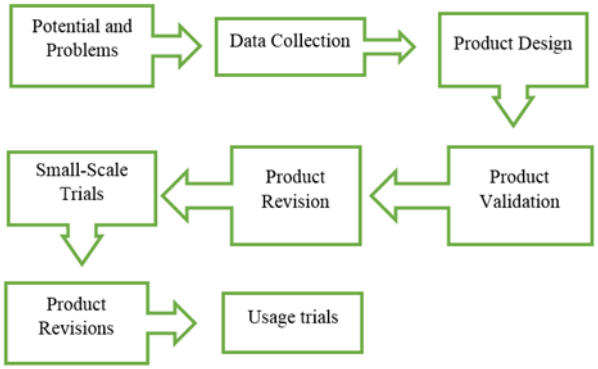

Figure 1. Research steps according to Borg & Gall

The first step taken was to carry out observations and interviews to find the potential and problems that exist in the school, then collect data on the results of the interviews, then design the product to be developed, after the initial product is finished, then validate it with experts. Next, carry out revisions to the product that has been developed, after that carry out a small scale trial to find out the response of teachers and students, then carry out revisions if there are suggestions and input from the teacher, and finally carry out use trials with students to measure how scientific literacy skills

Test Subjects

The test subjects in the research and development assessment to measure the science literacy ability of students on this straight-motion material were grade XI students of SMA Negeri 1 Gandapura, with a sample of 25 people from grade XI IPAS 1 and 25 people from grade XI IPAS 3. In this study, researchers used saturated sample techniques because researchers used the entire population as a sample.

Research Design

The research design stage aims to prepare science literacy assessment instruments. The steps at this stage make questions based on science licensing indicators: A Body of Knowledge, Way of Investigating, Way of Thinking, and Interaction of Science, Technology, and Society. We are designing a scientific literacy assessment instrument with multiple choices.

Data Collection Techniques

In this research, data collection techniques include the following:

1. Conduct interviews with teachers to obtain information related to problems in the school.
2. Submit several questions through expert validation questionnaires and teacher and student responses.
3. Measuring scientific literacy abilities, calculate question valididy, reliability, level of difficulty and distinguishing power.

Data Analysis Techniques

This data analysis technique in assessment and development uses the results of questionnaires as Likert scales that describe the data that experts and responses have filled in. The result criteria can be seen in Table 1.

Table 1. Expert eligibility result criteria

Percentage	Feasibility
$80 < P \leq 100\%$	Very Worth It
$60 < P \leq 80\%$	Proper
$40 < P \leq 60\%$	Pretty Decent
$20 < P \leq 40\%$	Less Decent
$0 < P \leq 20\%$	Not Worth It

Source: (Sa'adah & Wahyu., 2020)

Table 2. Response criteria of teachers and learners

Percentage	Feasibility
$80 < P \leq 100\%$	Very good
$60 < P \leq 80\%$	Good
$40 < P \leq 60\%$	pretty good
$20 < P \leq 40\%$	Not Good
$0 < P \leq 20\%$	Not Good

Source: (Sa'adah & Wahyu., 2020)

Question Item Validity

The validity of the question points in this development uses analysis with the Rasch Model. The validity results can be seen and analyzed with the Winstep program on the Misfit order table to determine the question items' suitability. The criteria for the validity of the question items in rasch modeling can be seen in Table 3.

Table 3. Question item validity criteria

Reference	Limit Value
Outfit Mean Square (MNSQ)	0.5 < MNSQ < 1.5
Outfit Z-Standard (ZSTD)	-2.0 < ZSTD < +2.0
Point Measure Correlation (Pt Mean Corr)	0.4 < Pt Mean Corr < 0.85

Source: (Sumintono & Widhiarso., 2015)

Reliability

Reliability testing in this research was carried out using the winstep program.

Reliability can be seen in the summary of estimation items, reliability of estimates in the Winstep application (Sumintono & Widhiarso, 2015). Reliability criteria use the following references.

Table 4. Person/item reliability criteria

Magnitude of r Value	Interpretation
> 0.98	Special
0,91 – 0,94	Very good
0,81 – 0,90	Good
0,67 – 0,80	Enough
< 0.67	Weak

Source: (Muliani et al., 2022)

Table 5. Cronbach alpha reliability criteria

Magnitude of r Value	Criterion
> 0.8	Very good
0.7 < < 0.8	Good
0.6 < < 0.7	Enough
0.5 < < 0.6	Bad
< 0.5	Very bad

Source: (Muliani et al., 2022)

Difficulty level

Difficulty levels are categorized based on logit and standard deviation (SD) measurements. The criteria for the level of difficulty in the Rasch model can be seen in the table 6.

Table 6. Difficulty level criteria

Measure value (logit)	Criterion
measure logit < - SD *logit*	Very easy items
SD *logit* ≤ *Measure logit* ≤ 0	Easy items
0 ≤ *Measure logit* ≤ SD *logit*	Hard items
Measure logit >*SD logit*	Very difficult items

Source: (Muliani et al., 2022)

Differentiating Power

In Rasch modeling, the discriminating power test uses the method of identifying groups of respondents based on the respondent separation index. The equation to find out the grouping more thoroughly is used stratum equation (H):

$$H = \frac{[(4 \times SEPARATION) + 1]}{3}$$

Analysis of the level of science literacy ability of learners

The science literacy ability of students is a benchmark for success in doing science literacy problems. The science literacy ability of students is also the average of the overall scores of the tests that have been done. The formula can measure the average value:

$$level\ literacy = \frac{total\ score}{high\ score} \times 100$$

Table 7. Science literacy categories

Percentage	Category
80 - 100	Very high
66 - 79	Tall
56 - 65	Keep
40 - 55	Low
0 - 39	Very low

Source: (Chasanah et al., 2022)

RESULTS AND DISCUSSION

Results

Expert validity analysis

The results of the validity of material experts and media experts can be seen in Table 8.

Table 8. Results of material expert validity

Validators	Number of scores	Percentage	Category
V1	37	74%	Proper
V2	41	82%	Very Worth It
	Average	78%	Proper

The results of validation carried out by material expert validators on the science literacy assessment that has been developed obtained a validation score from validator 1 of 37 with a percentage of 74% included in the eligibility criteria. Then, validator 2 received a score of 41 with a rate of 82% included in the very feasible standards. So, it can be concluded, based on experts, that the assessment material developed is possible to apply.

Table 9. Results of media expert validity

Validators	Number of Scores	Percentage	Category
V1	55	91,66%	Very Worth It
V2	50	83,33%	Very Worth It
	Average	87,49%	Very Worth It

Based on the results in the table above, the results of validation carried out by media experts on the assessment that has been developed obtained from validator 1 received a score of 55 with a percentage of 91.66% and in the very feasible category. Meanwhile, validator 2 obtained a score of 50 with a ratio of 83.33% and was included in the very decent category.

Analysis of teacher and learner responses

The results of the responses of teachers and participants can be seen below:

Table 10. Results of teacher response

Respondent	Number of Scores	Percentage	Criteria
G1	94	94%	Very good
G2	93	93%	Very good
	Average	93,5%	Very good

The results of the teacher's response to the assessment that has been developed are obtaining scores from teacher 1 with a score of 94 with a percentage of 94% and are included in the excellent criteria. While teacher 2 received a score of 93 with a ratio of 93% and was included in the excellent standards. And the average response results from both teachers showed excellent results.

Table 11. Results of student responses

Respondents	Score	Percentage	Criteria
S1	70	93,33%	Very good
S2	70	93,33%	Very good
S3	73	97,33%	Very good
S4	67	89,33%	Very good
S5	72	96%	Very good
S6	57	76%	Good
S7	71	94,66%	Very good
S8	58	77,33%	Good
S9	61	81,33%	Very good
S10	62	82,66%	Very good
	Average	88,13%	Very good

Based on the data, it can be concluded that the overall response results fall into the excellent category.

Question Item Validity

The results of the validity of the question items in this development can be seen in the following Winstep output results table.

Table 12. The result of the validity of the question item

Question Number	(MNSQ)	(ZSTD)	(Pt Mean corr)
S1	0,61	0,2	0,14
S2	0,47	-0,5	0,45
S3	0,45	-0,1	0,25
S4	1,08	0,5	0,23
S5	2,87	1,6	-0,2
S6	**4,78**	**2,1**	**0,12**
S7	0,53	-0,8	0,67
S8	0,57	0,0	0,22
S9	1,17	0,7	0,50
S10	0,85	-0,4	0,56
S11	1,07	0,4	0,23
S12	0,72	-0,1	0,39
S13	0,34	-0,3	0,37
S14	1,27	0,9	0,33
S15	0,86	-0,2	0,47
S16	1,05	0,3	0,61
S17	0,56	-1,6	0,79
S18	1,22	0,8	0,46
S19	0,40	-2,6	0,83
S20	**4,27**	**6,0**	**-0,20**
S21	0,39	-2,7	0,83
S22	0,39	-2,7	0,84

Based on the data above, from the 22 questions tested, there are 20 valid and two invalid questions. The two invalid questions were found not to meet all three criteria of Rasch modeling.

Reliability

The reliability results can be seen in Table 13.

Table 13. Reliability results on winstep output

	Value
Person Reliability	0,77
Item Reliability	0,90
Alpha Cronbach	0,80

From the results of the Winstep output above, the results were obtained at Person Reliability 0.77 and item reliability 0.90, So from the results of both it is concluded that the consistency of student responses is sufficient and the quality of the assessment questions is classified as good. Cronbach's Alpha value in measuring reliability shows a result between a person and an object of 0.80. These results show that the interaction between students and the questions as a whole is good.

Difficulty level

The difficulty level of the question item is one of the parameters that determines the quality of the question item. In this study, the difficulty level of the question items was determined through Rasch modeling. In Rasch modeling, difficulty levels are categorized based on logit value and standard deviation measurements. If the logit value is, it means the difficulty level of the question is relatively high. This study's standard deviation value (SD Logit) was +1.75. So, the level of difficulty in each question item. The results of the difficulty level in this study can be seen in Table 14.

Table 14. Results Distribution of item difficulty levels in winstep output

***Measure* value (logit)**	**Criteria**	**Item Number**
measure logit < - SD *logit*	Very easy items	6 item (1, 3, 4, 6, 8 and 13)
SD *logit* ≤ *Measure logit* ≤ 0	Easy items	4 item (2, 5, 11, and 12)

***Measure* value (logit)**	**Criteria**	**Item Number**
0 ≤ *Measure logit* ≤ SD *logit*	Hard items	9 item (9, 10, 14, 15, 18, 19, 20, 21, and 22)
Measure logit >*SD logit*	Very difficult items	3 item (7, 16, and 17)

In this study, the results of the separation index were obtained at 3.04. Then, the researcher will calculate the differentiating power using the formula:

$$H = \frac{[\,(4 \times SEPARATION) + 1]}{3}$$

$$H = \frac{[\,(4 \times 3{,}04) + 1]}{3}$$

$$H = \frac{13{,}16}{3} = 4{,}38$$

From the results above, it can be concluded that four categories of question items can be interpreted as very easy, easy, complicated, and very difficult questions.

Results of Science Literacy Measurement

This study develops assessments based on four aspects of science literacy. The assessment consists of four questions on the aspect of a body of knowledge, namely on numbers 1, 2, 10, 18, Eight questions on the element of the way of investigating, namely at numbers 5, 6, 8, 9, 11, 12, 15, 16, Five questions on the aspect of the way of thinking, namely at numbers 3, 4, 14, 19, 20 and three questions on the interaction of science technology aspect, namely at number 7, 13, 17. The results of science literacy in class XI science on straight-motion kinematics material can be seen in the following picture.

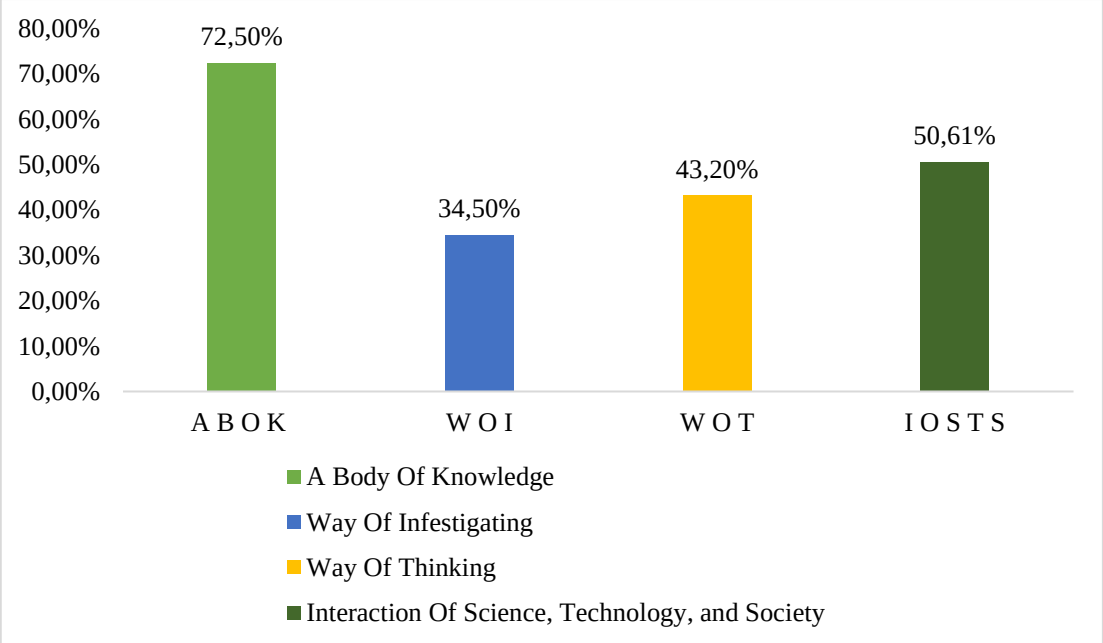

Figure 2. Science Literacy Results of Students

Based on the results above, it can be concluded that the science literacy ability of students in the aspect of science as a body of knowledge by 72.50% and is included in the high category. Then, the element of science as a way of investigating by 34.50% is included in the deficient category. In the aspect of science as a way of thinking by 43.20% and included in the low sort. The part of science is directly related to the

interaction of science, technology, and by 50.61% and is included in the low category.

Discussion

The research conducted by researchers at SMA Negeri 1 Gandapura refers to the Research and Development (R&D) development model. The model used by researchers in this development is a development model, according to Borg & Gall, which consists of ten stages. Still, this study uses eight steps.

This research begins with the potential problems in SMA Negeri 1 Gandapura, namely that the school has implemented an independent curriculum; in the independent curriculum, literacy ability is one of the assessment components. The use of science literacy-based questions in schools has also never been done; teachers still use ordinary questions as assessments, which certainly affects students' science literacy ability. The teacher admitted that he had never made a science literacy-based problem. Therefore, efforts must be made to train students to solve problems based on scientific literacy, in order to meet educational needs in the 21st century.

After collecting data, the next step is for researchers to design products. In this case, researchers will develop science literacy assessments based on aspects of science literacy and achievements in learning. This science literacy assessment format is designed with parts consisting of a preface, table of contents, introduction to science literacy, aspects of science literacy, and general instructions for use. The content section consists of science literacy questions on straight-motion material and discussion. Then, the concluding part consists of a bibliography. At this stage, researchers experience problems during the initial planning process of this assessment. These obstacles are that researchers have difficulty finding references related to science literacy, and some issues are not following scientific literacy indicators. Furthermore, researchers validate products to experts to see the feasibility of assessment products that have been developed.

Then, the researchers conducted a trial of questions developed for class XII students who had studied straight-motion kinematics material. This test uses rasch modeling, where this test is a modern question test. According to Rusilowati (2018), modern test theory, especially in the Rasch model, is very practical in conducting analysis, explanation, and conclusions from a test. The response pattern given shows the response accuracy from each respondent to each question item. In this study, of the 22 questions tested, two were invalid, so the questions were not suitable for use. Then the individual reliability results of 0.77 indicate that the consistency of students' answers is sufficient. Meanwhile, the reliability of the questions was 0.90, indicating that the quality of the questions items developed is included in the excellent category.

After getting a decent question, the researcher will test the assessment product to class XI students, where the results will measure students' science literacy on straight-motion material. Then, researchers will measure students' science literacy in the very low, low, medium, high, and very high categories. The results show that students' science literacy skills on straight-motion kinematics material are in the low category. Based on the results of the researchers' observations, the low science literacy of students is caused by the lack of interest in reading students. This is in line with research conducted by (Chasanah et al., 2022), which shows low science literacy ability due to students' lack of reading interest in addition to the importance of the teacher's role in training students to work on problems based

on science iterations.

Schwartz et al. (2006) said that each person's scientific literacy level is different; several factors, including differences in age, experience, knowledge, and environment, cause this. In addition, according to Fuadi et al. (2020), the low factor of scientific literacy is caused by several things, including (1) selection of textbooks, (2) non-contextual learning, (3) low reading ability, and (4) a less conducive learning environment and climate. Therefore, teachers play an essential role in the teaching and learning process to create learning that contains science literacy so that students' science literacy skills can be honed and can get used to doing science-based problems. According to Sumaryatun et al. (2016), the most appropriate action to improve students' science literacy is for teachers to start promoting learning that contains science literacy. Therefore, teachers play an essential role in the teaching and learning process to create learning that contains science literacy so that students' science literacy skills can be honed and can get used to science-based problems.

CONCLUSION

Based on the results of development and research, it can be stated that the assessment developed is suitable for use based on experts and the results of the validity of the questions; there are 20 valid questions with excellent item reliability, then the level of difficulty is grouped into four categories, namely the categories of very difficult, difficult, easy, very easy questions. The results of measuring students' science literacy on straight-motion kinematics material fall into the low category. The aspect of a body of knowledge is included in the high category, the element of the way of investigating is included in the very low category, the part of the way of thinking is included in the low category, the interaction aspect of science and technology is included in the low category.

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