JP2M (Jurnal Pendidikan dan Pembelajaran Matematika)
11 (1), 2025, 41-52

http://jurnal.stkippgritulungagung.ac.id/index.php/jp2m

RASCH MODEL ANALYSIS: DEVELOPMENT OF STUDENTS' NUMERACY LITERACY INTEREST INSTRUMENTS IN MATHEMATICS LEARNING

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Diserahkan: 08-01-2025; Direvisi: 18-01-2025; Diterima: 30-01-2025

Abstract: The low interest of students in numerical literacy remains a concern, necessitating a specific instrument to measure this aspect. This study aims to develop and validate an instrument for measuring interest in numerical literacy using the Rasch Model. The research subjects consisted of 200 randomly selected high school students in Jakarta. Data were collected through an online questionnaire based on a 5-point Likert scale. The analysis showed that 12 out of 13 items were valid and reliable, with an item reliability value of 0.89 and a Cronbach's Alpha of 0.92. The distribution of item difficulty levels was even, ensuring the instrument could measure students' interest across various ability levels. One item did not fit the validity criteria and needs revision. Additionally, the Rasch Model provided in-depth insights into response consistency and the distribution of item difficulty levels. The developed instrument significantly contributes to measuring interest in numerical literacy, supporting educational decision-making, and designing more effective learning interventions.

***Keywords**:* interest numeracy literacy; instrument; rasch model

How to Cite: Ambarwati, Dyah., Maarif, Samsul., (2025). Rasch Model Analysis: Development Of Students' Numeracy Literacy Interest Instruments In Mathematics Learning . *JP2M (Jurnal Pendidikan dan Pembelajaran Matematika), Vol.11 No.1,* (41-52). https://doi.org/10.29100/jp2m.v11i1.7279

Introduction

Numeracy literacy is an essential skill for secondary school students for understanding and applying mathematical concepts in everyday life. It includes the ability to utilize numbers and basic mathematical symbols in solve various practical problems (Alfiah et al., 2020). This skill involves analyzing information presented in different forms, such as graphs, tables, and charts, and applying the results of these analyses to make predictions and decisions. With numeracy literacy, individuals can solve problems based on mathematical principles in various contexts. (Hayati & Kamid, 2019).

In the modern era, numeracy literacy is not just the skill to count but also includes logical reasoning and mathematical problem-solving. However, it is evident that students show little interest in numerical literacy. In Germany, for example, there is a downward trend in students' interest in numeracy literacy, as it is often perceived as merely dealing with numbers, formulas, and abstract theorems, which can be challenging to understand (Azmidar et al., 2017). Moreover, students often feel frustrated when struggling to understand the material, which is primarily caused by their lack of interest in numeracy literacy.

According to the OECD, numeracy literacy plays a role in identifying and understanding the importance of applying mathematics in various aspects of life, both through data-based assessments and practical application of mathematical concepts. Mathematical literacy allows individuals to interact with the world of mathematics functionally, solve problems, and face the challenges of everyday life in a personal and meaningful way (Haara et al., 2021). This highlights the need to integrate numeracy literacy into real-life contexts to make it more engaging and relevant for students.

Studies have shown that fostering an early interest in numeracy literacy significantly improves student outcomes. Hidayati et al., (2024) emphasize that students' interest serves as a motivational foundation for their active engagement in learning activities. High interest correlates with better problem-solving skills and improved attitudes toward mathematics. Conversely, low interest often results in reduced motivation and learning inefficiencies.

Research by Amalia & Nuriadin (2023), Rohantizani et al., (2022), and (Yulia et al., 2021) shows that students' interest in numerical literacy plays a significant role in determining their understanding and skills in this area. Student interest in numerical literacy is a crucial aspect of mathematics learning at the secondary school level. High interest allows students to be more motivated in understanding and applying numeracy concepts in daily life, while low interest is often a barrier to successful learning (Rinaldi et al., 2021). Therefore, understanding students' interest in numeracy literacy is essential to improving their overall learning outcomes. High interest allows students to be more motivated in understanding and applying numeracy concepts in daily life, while low interest is often a barrier to successful learning.

Students' interest in learning numeracy literacy can be interpreted as interest, attention, enthusiasm, and internal motivation that drives someone to carry out a learning activity. Students who have a high interest in lessons usually show sincerity in learning, such as actively repeating the material independently (Apriyani & Sirait, 2021a). They also feel enthusiastic when participating in learning and remain motivated even though they face difficulties in solving numeracy literacy questions.

At the secondary school level, numeracy literacy not only prepares students for academic challenges but also equips them with critical skills for entering the workforce and society (Goos et al., 2018). However, specific instruments to measure students' interest in numeracy literacy are still limited. The validation of such an instrument is crucial to ensure that it accurately reflects students' interests so that educational interventions can be designed more effectively. Recent research shows that students' interest in numerical literacy is below the expected level. This highlights the need for efforts to increase this interest by developing appropriate instruments. (Rohantizani et al., 2022).

Some previous studies by Saputra & Nindiasari, (2024) and Suciati et al, (2020) have developed instruments to measure students' mathematical literacy achievements. These instruments show feasibility as a measurement tool, but they have not specifically addressed the aspect of interest in numeracy literacy. Therefore, the development and validation of instruments capable of measuring students' interest in numerical literacy are crucial for enhancing the quality of mathematics education. Research on numerical literacy in Indonesia continues to grow, focusing on teaching methods, evaluations, and curriculum development that support mathematical literacy (Ahyan et al., 2021).

Previous studies, Ambarwati & Kurniasih (2021) have conducted studies on numeracy literacy, particularly regarding on media and learning models related to numeracy literacy. However, students' interest in numeracy literacy has not been a primary focus, despite its significant influence on motivation and learning outcomes (Putri & Rifai, 2019) (Rista, 2022). In this context, developing an instrument specifically designed to measure students' interest is a crucial step in providing a comprehensive overview.

This study seeks to design and validate an instrument to assess the interest of secondary school students in numerical literacy. The measurement approach developed an instrument to determine the extent of students' interest, requiring analysis, particularly with Rasch Model analysis. The Rasch Model

ISSN 2460-7800 (*print*) | 2580-3263 (*online*)

is a measurement approach that can address several limitations of classical test theory, such as inadequate control over item difficulty levels, scaling, and appropriate ordering of ordinal response categories (Muhammad et al., 2023). Through this validation, it is hoped to produce a measurement tool that can provide an accurate picture of students' interest in numerical literacy, thereby supporting more effective and targeted mathematics learning decision-making.

Methods

Research Design

This study utilizes a research and development (R&D) methodology to design and validate an instrument for measuring secondary school students' interest in numerical literacy. The research framework employs the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate) (Maulana et al., 2023). This model is widely recognized in educational research for its structured approach to developing effective instructional tools and instruments (Branch, 2009).

The instrument was adapted from aspects highlighted by Luo et al. (2019), Lutfi et al. (2023), and Rohantizani et al., (2022) including four indicators of students' interest in numeracy literacy: 1) Enjoyment, 2) Students' Attention, 3) Students' Interest, and 4) Students' Engagement. To ensure contextual appropriateness, the instrument was first translated into Indonesian. Subsequently, 13 items were developed into a questionnaire.

Participants and Data Collection

The study involved 200 secondary school students in Jakarta who voluntarily completed a numeracy literacy interest questionnaire. Data collection was conducted systematically by identifying respondents according to the research objectives. The questionnaire was distributed through Google Forms after obtaining participants' consent. Data collection was carried out between November 4, 2024, and December 11, 2024. The participants were categorized based on gender, school level, and age, as summarized in Table 1.

Table 1 . Respondent Details

Respondent	Gender		School Level			Age						
	M	F	JHS	SHS	VS	12	13	14	15	16	17	Total
Frequent	116	84	74	50	76	4	26	20	35	46	69	200
Percent %	58%	42%	37%	25%	38%	2%	13%	10%	17,5%	23%	34,5%	100%

From the data obtained, the range of students is from the middle school level, including junior high school, senior high school, and vocational school (JHS, SHS, and VS). From the age, the range is from 12 to 17 years old. The total number of research subjects is 200 students.

Instrument

The numeracy literacy interest instrument was adapted from the aspects proposed by Luo et al. (2019), Lutfi et al. (2023), and Rohantizani et al., (2022) and covered four indicators of interest indicators that have been developed. The measurement instrument consists of 13 items of student numeracy literacy interest statements. Of the 4 aspects, consisting of 1) Feelings of pleasure towards numeracy literacy, there are 3 statement items, 2) Students' attention to numeracy literacy, there are 3 statement items, 3) Students' interest in numeracy literacy, there are 4 statement items, and 4) Students' involvement in numeracy literacy, there are 3 statement items.

Data collection was conducted using a Likert-scale questionnaire comprising 13 statements categorized into five levels: 1) Strongly Disagree, 2) Disagree, 3) Neutral, 4) Agree, and 5) Strongly

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Agree. These 13 statements are coded as "M" (representing "Minat" or Interest), ranging from M1 to M13. The distribution of statement items is described in Table 2.

Table 2. Details of the Distribution of Statement Items in the Research Instrument

Aspects	Item Number	Statement Item Code	Number of Items
Good Feelings	1, 2, 3	M1, M2, M3	3
Student Attention	4, 5, 6	M4, M5, M6	3
Student Interest	7, 8, 9	M7, M8, M9, M10	4
Student Engagement	11, 12,1 3	M11, M12, M13	3
Total			**13**

From the 13 statement items that have been developed, a questionnaire instrument was distributed to a range of secondary schools in Jakarta, to test its validity and reliability.

Data Analysis Technique

Data analysis using the Rasch model by utilizing Winstep software, by calculating reliability and validity content, is done by measuring the content validity ratio and seen from the Rasch Model test results on the value of item fit/item fit order, included values: Outfit Mean Square/MNSQ, Outfit Z-Standart/ZSTD, and Point Measure Correlation/Pt. Mean Corr. This is based on the Items Fit Order in Table 3 (Sumintono & Widhiarso, 2015).

Table 3. Items Fit Order Criteria

Index	Validity Criteria
OUT.MNSQ (Mean Square)	$0.5 \leq$ MNSQ ≤ 1.5
OUT.ZSTD (Standardized Z-Score)	$-2 \leq$ ZSTD $\leq +2$
PT Measure Correlation	$0.4 \leq$ PT.Measure Correlation ≤ 0.85

Then for the reliability test criteria the criteria listed in Table 4 (Ngadi, 2023).

Table 4. Reliability

Quality of Items	Type of Measurement	Description
Reliability (Person/Item)	Person Reliability Item reality	a) n < 0.67: Weak
		b) 0.67–0.80: Moderate
		c) 0.81–0.90: Good
		d) 0.91–0.94: Very Good
		e) n > 0.94: Excellent
Overall Reliability	Cronbach's Alpha	a) n < 0.5: Very weak
		b) 0.5–0.6: Weak
		c) 0.6–0.7: Moderate
		d) 0.7–0.8: Good
		e) n > 0.8: Excellent

Instrument reliability was tested using item reliability and person reliability values, and Cronbach's Alpha to assess internal consistency. Additionally, the difficulty level of each item was analyzed using logit values to determine their distribution of items in the difficult, medium, and easy categories. This method provided a comprehensive approach to evaluating the instrument's quality, ensuring its validity and reliability for measuring students' interest in numeracy literacy.

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Results and Discussion

Results

Table 5 lists the results of the Rasch Model analysis performed by 200 students at the secondary school level using the Winstep software instrument application.

Table 5. Measures of Problem Difficulty Level & Statistical Suitability of RASCH Model Analysis

No.	Statement Item	Item Code	Measure	MNSQ Outfit	ZSTD Outfit	PT-Measure Corr.
1	I enjoy understanding numbers and mathematical symbols related to numeracy literacy.	M1	0,01	0,72	-2,92	0,80
2	I enjoy learning numeracy literacy related to everyday life.	M2	-0,24	0,95	-0,43	0,74
3	I find numeracy literacy the most interesting part of mathematics lessons.	M3	0,00	0,65	-3,85	0,81
4	I always pay full attention when the teacher explains numeracy literacy material.	M4	-0,55	0,96	-0,29	0,62
5	I try to carefully understand each step in numeracy literacy.	M5	-0,25	2,36	9,41	0,32
6	I take notes and listen attentively to the teacher's explanation of numeracy literacy.	M6	0,26	1,06	0,56	0,69
7	I found out more about numeracy literacy issues that I find difficult to understand.	M7	0,18	0,74	-2,72	0,76
8	I feel challenged to solve numeracy literacy because it is relevant to my daily life.	M8	0,10	0,61	-4,39	0,81
9	I am interested in learning numeracy literacy because it is relevant to my daily life.	M9	0,47	0,70	-3,23	0,80
10	I am enthusiastic about immediately completing the numeracy literacy task given by the teacher.	M10	-0,51	1,04	0,41	0,71
11	I actively follow the tasks given by the teacher related to numeracy literacy.	M11	0,21	0,58	-4,80	0,83
12	I try to analyze stories, tables, graphs, or diagrams and try to conclude.	M12	0,37	1,42	3,67	0,61
13	I often participate in group activities related to numeracy literacy.	M13	-0,05	1,07	0,73	0,70

Notes: MNSQ = Mean Square; PT-Measure CORR. = Point Measurement Correlation

From the analysis of the 13 statement items of the student interest instrument on numeracy literacy. From the presentation of Table 5 shows that the Outfit Mean Square (MNSQ) instrument item value of 12 statement items fits the criteria between 0,72 to 1,42 (with the criteria MNSQ outfit, namely 0,5 to 1,5), but 1 statement item with item code M5 does not fit the correlation criteria with a value of 2,36. Table 3 shows the value PT-Measure CORR of 12 statement items fits criteria 0,61 to 0,83 (with correlation criteria, namely 0,4 to 0,85), but 1 statement item with item code M5 does not fit the correlation criteria with a value of 0,32. So, overall of the 13 statement items of the student interest instrument on numeracy literacy. 12 items fit the model which is assessed at a suitable and productive

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level to measure the numeracy literacy interest scale. However, 1 item with the code M5 does not fit these criteria. Thus, 12 items with codes (M1, M2, M3, M4, M6, M7, M8, M9, M10, M11, and M13) are considered to fit the model assessed at a suitable and productive level to measure the numeracy literacy interest scale.

To see the results of the Reliability analysis of the numeracy interest questionnaire instrument with the Rasch Model presented in Figure 1

PERSON	200 INPUT	200 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	49.2	13.0	1.00	.40	.99	-.2	.99	-.2
P.SD	10.4	.0	1.13	.11	.64	1.5	.63	1.5
REAL RMSE	.42	TRUE SD	1.05	SEPARATION	2.51	PERSON RELIABILITY		.86
ITEM	13 INPUT	13 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	756.2	200.0	.00	.10	1.00	-.7	.99	-.6
P.SD	36.6	.0	.30	.02	.51	4.1	.46	3.7
REAL RMSE	.10	TRUE SD	.29	SEPARATION	2.91	ITEM RELIABILITY		.89

Figure 1. Reliability

Based on Figure 1, the reliability value for all items is 0,89. This shows that the question items have very good quality. Meanwhile, the Person reliability value of 0,86 means that respondents have good consistency in answering questions. The Cronbach Alpha value is shown in Figure 2.

SUMMARY OF 200 MEASURED PERSON

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	49.2	13.0	1.00	.37	.99	-.19	.99	-.18
SEM	.7	.0	.08	.01	.05	.11	.04	.10
P.SD	10.4	.0	1.13	.08	.64	1.50	.63	1.47
S.SD	10.4	.0	1.13	.08	.64	1.50	.63	1.48
MAX.	62.0	13.0	3.09	1.00	4.50	4.77	4.24	4.56
MIN.	14.0	13.0	-3.96	.29	.09	-4.76	.09	-4.69
REAL RMSE	.42	TRUE SD	1.05	SEPARATION	2.51	PERSON RELIABILITY		.86
MODEL RMSE	.38	TRUE SD	1.06	SEPARATION	2.80	PERSON RELIABILITY		.89
S.E. OF PERSON MEAN = .08								

PERSON RAW SCORE-TO-MEASURE CORRELATION = .99
CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .92 SEM = 2.93
STANDARDIZED (50 ITEM) RELIABILITY = .97

Figure 2. Reliability Cronbach Alpha

Then the Reliability Cronbach Alpha value obtained a value of 0,92, including in the Special category. This shows the very high internal consistency of the instrument. So the overall instrument of the student interest questionnaire on numeracy literacy that has been developed is reliable and consistent.

To show the difficult parameter of each item, it can be seen from the logit value presented in Figure 3.

ISSN 2460-7800 (*print*) | 2580-3263 (*online*)

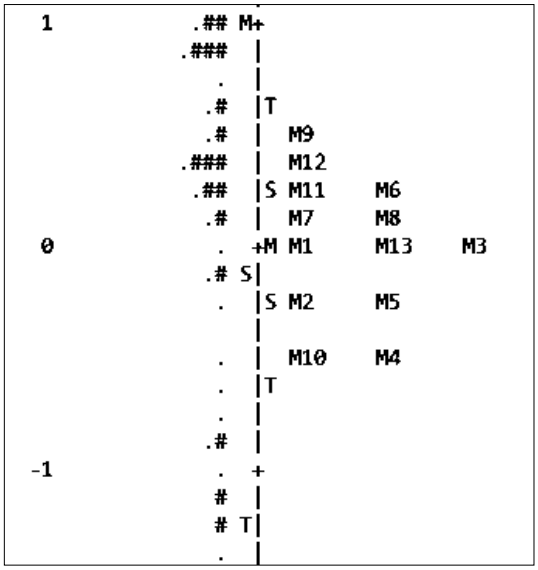

Figure 3. Distribution of Item Difficulty Levels

From the distribution, it can be seen from Figure 3, that the difficulty level of the items is analyzed through the logit value. The distribution of difficulty levels shows an even distribution in the difficult, medium, and easy categories.

ITEM STATISTICS: MEASURE

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	JMLE MEASURE	MO S.
9	697	200	.47	
12	710	200	.37	
6	725	200	.26	
11	731	200	.21	
7	735	200	.18	
8	745	200	.10	
1	757	200	.01	
3	758	200	.00	
13	764	200	-.05	
2	786	200	-.24	
5	787	200	-.25	
10	816	200	-.51	
4	820	200	-.55	
MEAN	756.2	200.0	.00	
P.SD	36.6	.0	.30	

Figure 4. Measure Distribution

The overall item difficulty levels are evenly distributed, indicating that the numeracy literacy interest instrument is well-balanced. The most challenging item for students to answer is item M9, which states: "*I am interested in learning numeracy literacy because it is relevant to my daily life*." The logit position of this item shows that it requires a higher level of numeracy literacy interest to answer correctly. On the other hand, the easiest items for students to answer are items M10 and M4, which state "*I am enthusiastic to immediately complete the numeracy literacy task given by the teacher*." and "*I always pay close attention when the teacher explains numeracy literacy material*." These items have low logit values, showing that they are easier for students with lower levels of numeracy literacy interest to respond to. Thus, the distribution of item difficulty shows that the instrument includes a range of items, from easy to difficult, making it capable of measuring students' interest in numeracy literacy across varying ability levels. To verify the suitability of category responses, this is shown through the item response category curve, as shown in Figure 5.

ISSN 2460-7800 (*print*) | 2580-3263 (*online*)

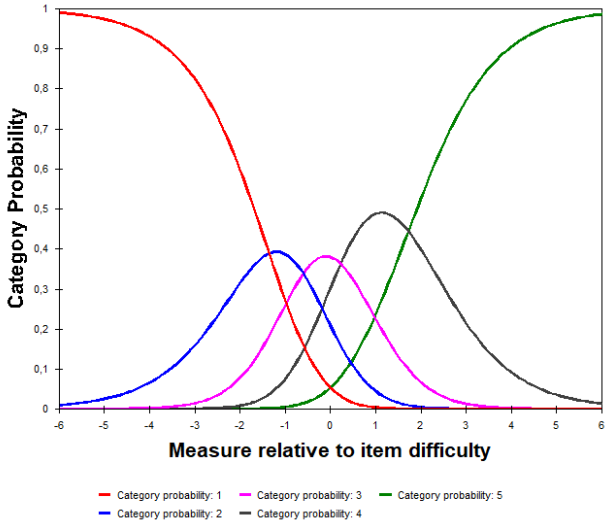

Figure 5. Kurva Kategori Respons Item

Figure 5 shows the numeracy literacy interest curve values, consisting of a Likert scale with 5 answers on the corresponding item response category curve. It can be seen that the Distribution Pattern of each category has a maximum probability peak at a certain ability range. This shows that students with different abilities tend to choose the category that matches their ability level. As the curve shows, the Likert Scale with 5 answer categories has a consistent distribution pattern. The intervals between categories look relatively stable, indicating an effective interval scale. There is no excessive overlap between categories, so the responses of each category provide unique information. The item response category curves show that this instrument has an effective Likert scale, with consistent category distribution and stable scale intervals. This supports the validity of using the scale in the instrument to accurately measure students' numeracy literacy interest. The curves show that the use of Likert scales in this instrument is appropriate for measuring students' numeracy literacy interest.

Discussion

The results of this study provide some important implications for the field of education and the measurement of students' interest in numeracy literacy. In general, the instruments developed from the aspects proposed by Luo et al. (2019), Lutfi et al. (2023), and Rohantizani et al., (2022) proved to be valid and reliable, with an even distribution of item difficulty levels. This shows that the instrument is capable of measuring students' interest across various ability levels, from low to high. The success of this instrument in measuring the validity and reliability criteria indicates that the Rasch Model approach is effective for evaluating Likert scales. The high-reliability values confirm that both the items and the respondents provide consistent and reliable data. Thus, this instrument can be used for similar research in the future or for learning evaluation. However, the analysis results showed that one item (M5) did not fit the validity criteria, with an overestimated Outfit MNSQ value and low correlation. These results indicate that the 12 items of the instrument can be considered valid to measure students' interest in numeracy literacy, while item M5 needs to be revised.

In terms of item difficulty, the results show an even distribution between easy, medium, and difficult categories. The most difficult item, M9, provides insight into an aspect of numeracy literacy that may require more attention in the learning process, which is the relevance of numeracy literacy to daily life. In contrast, the easiest items, such as M10 and M4, show that students tend to be more comfortable with numeracy literacy activities that are practical and directed. The item response category curves also show that the 5-point Likert scale used in this instrument has consistent intervals and a clear

ISSN 2460-7800 (*print*) | 2580-3263 (*online*)

distribution of categories. This ensures that the scale provides data that can be accurately interpreted to measure students' interests.

Overall, this study contributes to Lince et al., (2023) and Apriyani & Sirait, (2021), previous research on learning interest has been significant in developing a numeracy literacy interest measurement tool. With high validity and reliability, this instrument can be used to support educational decision-making, such as designing more effective learning interventions and increasing student motivation in numeracy literacy. In addition, this study provides a basis for the development of similar instruments in the future, with recommendations to revise the invalid items and further explore the factors that influence students' interest in numeracy literacy.

Conclusion

This study successfully developed and validated an instrument to measure students' interest in numeracy literacy using the Rasch Model. The analysis showed that 12 out of 13 items met the validity and reliability criteria, with an item reliability value of 0.89 and respondent reliability of 0.86. The instrument also has excellent internal consistency, evidenced by a Cronbach's Alpha value of 0.92. The even distribution of item difficulty levels ensured that the instrument was able to measure the interest of students of different ability levels. However, one item (M5) did not fit the validity criteria and needs to be revised to improve the quality of the instrument. The response category curve shows that the Likert scale used had consistent intervals and can be interpreted accurately. Of the 13 statement items, 12 items are valid, so they can be used to measure interest in numeracy literacy. This instrument makes a significant contribution to the measurement of numeracy literacy interest, as well as supporting more effective educational decision-making. Further recommendations include the revision of invalid items and additional exploration of the factors that influence students' interest in numeracy literacy.

Acknowledgment

The researcher expresses gratitude to all parties involved and the relevant experts for their invaluable support and guidance in ensuring the successful completion of this study. It is hoped that this research can serve as a reference and guideline for other researchers.

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