PROSIDING DISKUSI PANEL NASIONAL PENDIDIKAN MATEMATIKA

Original Research

Evaluation of the Level of Literacy Mathematics and Adversity Quotient Students Using Rasch Model Analysis

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INFO ARTICLES

Key Words:

Mathematical literacy, Adversity quotient, Rasch model

Abstract**:** *Mathematical literacy enables students to apply mathematics in real-life situations, while Adversity Quotient (AQ) supports persistence in overcoming academic challenges. This study aimed (1) to evaluate students' mathematical literacy using Rasch Model analysis, (2) to evaluate students' AQ, (3) to identify item difficulty levels in the mathematical literacy and AQ instruments, and (4) to identify items that did not fit the Rasch model. A quantitative survey was conducted with 555 junior and senior high school students. Data were analyzed using Winsteps software. The results showed that 11 of 14 mathematical literacy items and 10 of 20 AQ items fit the Rasch model. Female students demonstrated higher mathematical literacy and AQ than male students. Age significantly influenced mathematical literacy among female students but not among male students, whereas age significantly affected AQ in both male and female students. Several items require revision to improve instrument validity and reliability.*

Abstrak: Literasi matematika membantu siswa menerapkan matematika dalam kehidupan sehari-hari, sedangkan Adversity Quotient (AQ) mendukung ketahanan dalam menghadapi tantangan akademik. Penelitian ini bertujuan (1) mengevaluasi tingkat literasi matematika siswa menggunakan analisis Model Rasch, (2) mengevaluasi tingkat AQ siswa, (3) mengidentifikasi tingkat kesulitan butir pada instrumen literasi matematika dan AQ, serta (4) mengidentifikasi butir yang tidak sesuai dengan Model Rasch. Penelitian kuantitatif dengan metode survei melibatkan 555 siswa SMP dan SMA. Data dianalisis menggunakan perangkat lunak Winsteps. Hasil menunjukkan 11 dari 14 butir literasi matematika dan 10 dari 20 butir AQ sesuai dengan Model Rasch. Siswa perempuan memiliki literasi matematika dan AQ lebih tinggi dibandingkan siswa laki-laki. Usia berpengaruh terhadap literasi matematika pada siswa perempuan, sedangkan AQ dipengaruhi usia pada siswa laki-laki maupun perempuan. Beberapa butir perlu direvisi untuk meningkatkan validitas dan reliabilitas instrumen.

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How to Cite (APA 6th Style): Rahmadhar, F., Putri, N. T., Oktaviani, D. C., Abdullah, A. F., Faradillah, A., & Ulfah, S. (2026). Evaluation of the Level of Literacy Mathematics and Adversity Quotient Students Using Rasch Model Analysis. *Prosiding Diskusi Panel Nasional Pendidikan Matematika*, 157-168.

INTRODUCTION

Mathematical literacy refers to a student's ability to formulate, apply, and interpret mathematics in a variety of real-life contexts (OECD, 2022). This ability encompasses mathematical reasoning and the use of mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena (OECD, 2018). In the context of learning, mathematical literacy is not only concerned with computational skills, but also the ability to connect mathematical knowledge with real-world situations that are meaningful to students (Geiger et al., 2015; Fanggidae et al., 2024). Interest in mathematical literacy has grown considerably since the introduction of the Programme for International Student Assessment (PISA) by the OECD as an international assessment measuring students' ability to use mathematics to solve contextual problems. However, Indonesian students' achievement remains relatively low. The results of PISA 2022 indicate that Indonesia ranked 68th out of 81 countries, only 18% of students attained at least Level 2 proficiency in mathematics, compared to an OECD average of 69% (OECD, 2022). This condition suggests that many students have yet to optimally connect mathematical concepts with real-world problems.

As an effort to improve this capability, the Indonesian government has implemented. A comparable pattern is evident at the national level, where the proportion of students meeting the minimum numeracy competency stood at only 67.94% in 2024 (Kemendikdasmen, 2025). Despite this upward trend, the relatively low baseline in 2022 when more than half of students had yet to reach the minimum standard reinforces the weak mathematics performance already indicated by the PISA results, suggesting that the numeracy gap is not confined to the international assessment context but is also evident in domestic measurement. Therefore, mathematical literacy has become one of the important aspects that needs to be continuously evaluated .

Beyond cognitive factors, students' ability to solve mathematical problems is also influenced by psychological factors, one of which is Adversity Quotient (AQ). AQ is a form of adversity intelligence that describes a student's capacity to face, manage, and overcome various difficulties encountered (Stoltz, 2000). According to Amanah (2014), AQ represents a student's ability to transform obstacles into opportunities in achieving success. Stoltz (2000) categorizes AQ into three levels, namely climber, camper, and quitter. In mathematics learning, AQ plays a significant role because students are frequently confronted with problems that require perseverance, determination, and resilience in formulating, applying, and interpreting mathematical concepts. Various studies have shown that students with high AQ tend to demonstrate stronger mathematical literacy, as they are more persistent and resourceful in formulating, applying, and interpreting mathematics when faced with challenging real-life problems, compared to students with low AQ (A. Faradillah & Humaira, 2022; Fertikawati et al., 2025; Puspita et al., 2023; Ramadhani et al., 2023). Low AQ negatively impacts students' mathematical literacy, as students with low resilience tend to give up easily when faced with challenging contextual mathematics problems, resulting in weaker mathematical literacy performance particularly in formulating real world problems mathematically, employing relevant mathematical concepts and procedure, and interpreting the results within their real life context (Puspita et al., 2023; Ramadhani et al., 2023). Furthermore, students with low AQ tend to experience higher levels of mathematical anxiety, which reduces their engagement in mathematics learning (Liu et al., 2026). This condition highlights the importance of measuring AQ in order to gain an accurate picture of students' readiness to face various challenges in mathematics learning.

Measuring students' mathematical literacy and AQ requires valid and reliable instruments so that the results obtained can accurately reflect students' actual conditions. One widely used approach for evaluating the quality of instruments is the Rasch Model. The Rasch Model offers advantages in transforming ordinal data into interval data, and is capable of identifying item difficulty levels, respondent ability, instrument reliability, and the fit of items to the measurement model (A. Faradillah & Adlina, 2021; Widyaningrum et al., 2024) (A. Faradillah & Adlina, 2021; S. Faradillah, 2022). Unlike Classical Test Theory (CTT), which produces item and person statistics that are dependent on sample characteristics and relies on ordinal raw scores that do not meet the assumptions of interval-scale measurement (Stemler, 2021), the Rasch Model generates sample-free and test-free estimates,

yielding more accurate and objective measurements (Stemler, 2021). Moreover, it surpasses other Item Response Theory (IRT) models by maintaining the invariance of measurement scale, ensuring that the measurement scale retains the same meaning across different groups of test-takers (Stemler, 2021).

Several studies have utilized the Rasch Model in the field of mathematics education. (Suri et al., 2025) examined students' AQ and mathematical literacy through the implementation of the Cooperative Integrated Reading and Composition (CIRC) learning model using a quantitative approach with a quasi experimental design. Another study by (Widyaningrum et al., 2024) analyzed students' mathematical literacy using the Rasch Model, while (Dinda et al., 2023) examined critical thinking skills based on AQ. These findings suggest that the Rasch Model is effective for evaluating various educational instruments; however, research on mathematical literacy and AQ still tends to be conducted separately.

Based on the relevant studies, a research gap remains in the evaluation of mathematical literacy and Adversity Quotient (AQ) instruments. Suri et al., (2025) investigated students' AQ and mathematical literacy using a quantitative quasi-experimental approach through the Cooperative Integrated Reading and Composition (CIRC) learning model, while Widyaningrum et al., (2024) analyzed mathematical literacy using the Rasch Model and Dinda et al., (2023) examined students' critical thinking skills based on AQ. However, these studies either focused on learning outcomes or examined only one construct. To the best of the authors' knowledge, limited studies have simultaneously evaluated the psychometric quality of both mathematical literacy and AQ instruments using the Rasch Model. Therefore, the novelty of this study lies in evaluating the psychometric quality of mathematical literacy and Adversity Quotient instruments using the Rasch Model, providing evidence of item difficulty, validity, and reliability for instruments that can be appropriately used in mathematics learning. Therefore, this study aims to, (1) evaluate the level of students' mathematical literacy using Rasch Model analysis, (2) evaluate the level of students' adversity quotient, (3) identify item difficulty levels in both the mathematical literacy and adversity quotient instruments, and (4) identify items that do not fit the Rasch model.

METHOD

This study employed a quantitative research approach using a survey method. According to Setiawan et al., (2022), survey research is a type of research used to collect data from a population sample through questionnaire instruments in order to systematically analyze the influence or relationship among the variables under study. Furthermore, (Herdianti & Muntazimah, 2023) state that survey-based quantitative research is a research approach used to collect data from a population through validated questionnaire instruments, with the aim of identifying the influence among variables in a learning context. The survey approach was selected in this study because it allows researchers to obtain a comprehensive description of students' mathematical literacy levels and AQ based on data collected directly from respondents through a developed and validated questionnaire instrument.

Data were collected through the development of an instrument in the form of a questionnaire, which was constructed and validated prior to use. The questionnaire was developed to measure two main variables: students' mathematical literacy levels and AQ. The instrument development process encompassed item construction, validity testing, and reliability testing using Rasch Model analysis. Demographic information of the respondents is presented in Table 1 below.

Table 1. Subject Demographic Codes

Num.	Demographics Aspects	Category	Code	Frequency
1.	Educational Level	Junior High School	H	121
		Senior High School	I	434

Num.	Demographics Aspects	Category	Code	Frequency
2.	Age	14-16	W	439
		17-19	X	116
3.	Gender	Female	P	279
		Male	L	276

Table 1 presents the demographic distribution of 555 subjects. In terms of educational level, senior high school students were more that three times the of junior high school students. Based on age, 16-year-old students accounted for nearly half of the total subjects (47.9%). In terms of gender, the number of respondents was relatively balanced. This composition indicates that the sample was predominantly drawn from senior high school students in the middle-adolescent age range, with a near-equal representation of male and female respondents.

To assess the mathematical literacy of the participants, this study used mathematical literacy instruments by adopting all seven indicators of mathematical literacy as defined in the PISA framework (OECD, 2023). It assesses seven key competencies, namely communication, mathematizing, representation, reasoning and argument, devising strategies for solving problems, using symbolic, formal and technical language and operations, and using mathematical tools . These indicators were selected because they comprehensively represent students' ability to formulate, employ, and interpret mathematics in a variety of real-world contexts, providing a holistic assessment of mathematical literacy, The inclusion of indicators ranging from communication and mathematizing to the use of mathematical tools reflects a holistic view of mathematical literacy, covering both cognitive and procedural dimensions. This comprehensiveness is a notable strength, as many studies tend to measure only selected indicators, potentially underrepresenting the full construct (Sumarni, 2023). The indicators are well-aligned with the demands of real-world mathematical application. For instance, the mathematizing indicator, which involves transforming real-world problems into mathematical forms and interpreting results back into context (OECD, 2023; Hwang & Ham, 2021). This alignment strengthens the instrument's ecological validity, Each indicator is scored on a 1-5 scale, This scoring range provides reasonable measurement sensitivity to differentiate students across performance levels. However, the instrument's reliability and validity would be further strengthened if the scoring rubric for each level (1 through 5) were explicitly defined, particularly to minimize subjectivity in scoring the communication and reasoning indicators, which tend to involve open-ended responses (Santika & Khotimah, 2023).

This study used The Adversity Quotient construct and instrument by adopting instrument were originally developed by Stoltz (1997), who introduced the four CO2RE dimensions Control, Origin and Ownership, Reach, and Endurance and operationalised them in the Adversity Response Profile (ARP). The instrument used in the present study was adapted from this original conceptualisation through more recent operationalisations of the CO2RE framework (Anwar, 2024; Gradini & Noviani, 2025). AQ was assessed using a questionnaire adapted from the Likert-scale instrument developed by Gradini and Novianti (2025). Each item was rated on a four point Likert scale. Positively worded items were scored from 1 indicating strongly disagree to scored 4 indicating strongly agree, whereas negatively worded items were scored in the reverse order.

To obtain valid and trustworthy data, the research instruments were carefully reviewed and validated prior to their implementation in the study. Prior to data collection, the instrument was subjected to a validation process to ensure its validity and suitability for the study. This validation step was conducted to confirm that the instrument was appropriate for use before it was administered to the participants. Content validity is the degree to which an assessment instrument adequately and comprehensively represents the construct being measured, ensuring that all relevant aspects of the concept are covered and that the test items accurately reflect the intended learning objectives (Isaac et al., 2022; Viktor Pandra, 2023). In this study, the mathematical literacy ability test and the Adversity Quotient (AQ) questionnaire were validated by three expert validators, consisting of a mathematics education lecturer, a senior high school mathematics teacher, and an English lecturer.

The mathematics education lecturer assessed the accuracy of the mathematical content, item construction, and problem formulations to ensure that no conceptual or structural errors were present in the test items. The senior high school mathematics teacher evaluated whether the level of difficulty and content of the items were appropriate for students' cognitive abilities and aligned with the senior high school curriculum. In addition, the English lecturer reviewed the questionnaire and test items to ensure linguistic accuracy, clarity, readability, and the absence of grammatical or writing errors that could potentially influence students' interpretations of the items. Based on the experts' comments and recommendations, necessary revisions were made to improve the quality of the instrument. Furthermore, construct validity was examined using Rasch Model analysis to determine the extent to which the instrument accurately measured the intended constructs.

After the instrument was declared content-valid, the responses of the 555 respondents were analyzed using the Rasch model with the Winsteps application (version 3.73) to examine the suitability of each item. An evaluation of item appropriateness was performed to identify which items were suitable for measuring the intended constructs (Natanael, 2021). Three indicators were used as references, namely the Mean Square (MNSQ), the Z-Standardized (ZSTD), and the Point-Measure Correlation (PT-Measure Corr) (S. Faradillah, 2022)The acceptance criteria for each indicator are presented in Table 2. An item is considered fit when it satisfies at least two of these three criteria; bold values in the tables indicate scores that did not meet the corresponding criterion. The item fit results for the mathematical literacy instrument are presented in Table 2.

Table 2. Misfitting Items Fit of the Mathematical Literacy and Adversity Quotient

Num.	Instrument	Item	Outfit MNSQ (0.5 < x < 1.5)	Outfit ZSTD (-2,0 < x < 2.0)	PT-Measure Corr (0.4 < x < 0.85)
1.	Mathematical Literacy	D13	1.49	**7.0**	**.34**
		D14	1.49	**7.1**	**.36**
		D1	1.25	**3.1**	**.25**
2.	Adversity Quotient	F4	1.50	**7.7**	**.29**
		F5	1.33	**5.5**	**.31**
		F10	1.30	**5.0**	**.20**
		F11	1.20	**3.3**	**.30**
		F20	1.15	**2.5**	**.31**

Table 2 describes the results of the analysis generated from item fit for the literacy test and the AQ instrument, Items presented in Table 2 were classified as misfit because they failed to meet at least two of the three Rasch item fit criteria, MNSQ, ZSTD, Point Measure Correlation (PTMEA Corr) (Linacre, 2020; Susanto et al., 2023). The bold numbers indicate that the value does not fulfill one of the specified criteria. Subsequently, a reliability assessment will be conducted. This test procedure serves to evaluate the degree to which a research instrument is capable of generating consistent and dependable data (Dorsah, 2026). The reliability standards applied in this study encompass Cronbach's alpha with a threshold of > 0.50, along with item and person reliability classified as good (0.81–0.90), very good (0.91–0.94), and excellent (> 0.94), whereby the outcomes obtained through Winsteps are displayed in the figure below (S. Faradillah, 2022).

RESULT

This study used a Rasch Model analysis approach to examine broadcast subject responses gathered from distributed questionnaires. The analysis included data exploration grounded in three primary demographic dimensions: educational background, gender, and age grup. The analysis also included data exploration through Wright Maps visualization using the Winsteps application, which maps the position of individuals (ability) and items (difficulty level) on the same logit scale.

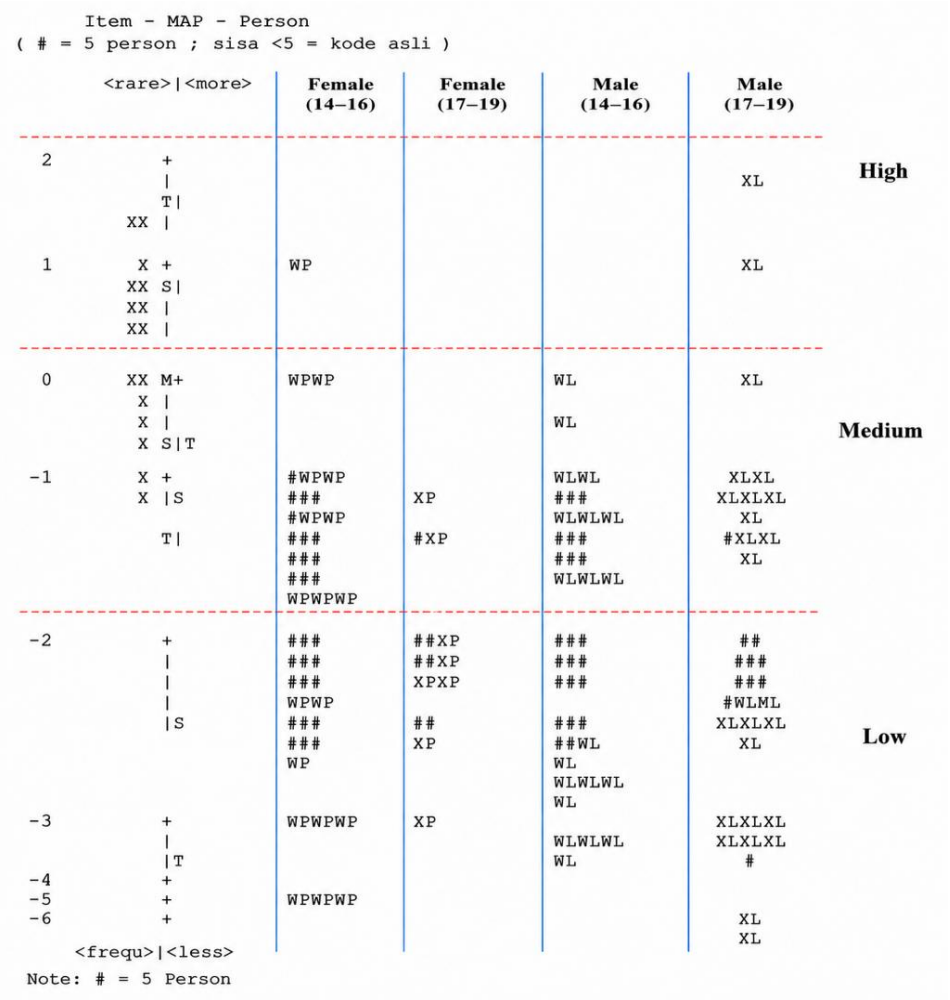

Figure 1. Wright Maps of Adversity Quotient by Gender and Age

Based on Figure 1, the Male (17–19) group tended to have higher AQ levels compared to the other groups, while the Female (14–16) group tended to fall in the lowest category. This pattern is consistent with findings that significant differences in AQ exist between male and female students, where gender and age factors contribute to individual resilience in facing learning difficulties (Agustina, 2021; Utami et al., 2024). Furthermore, to examine how students' mathematical literacy ability is distributed across gender and age categories, the Wright Maps visualization is presented in Figure 2 below.

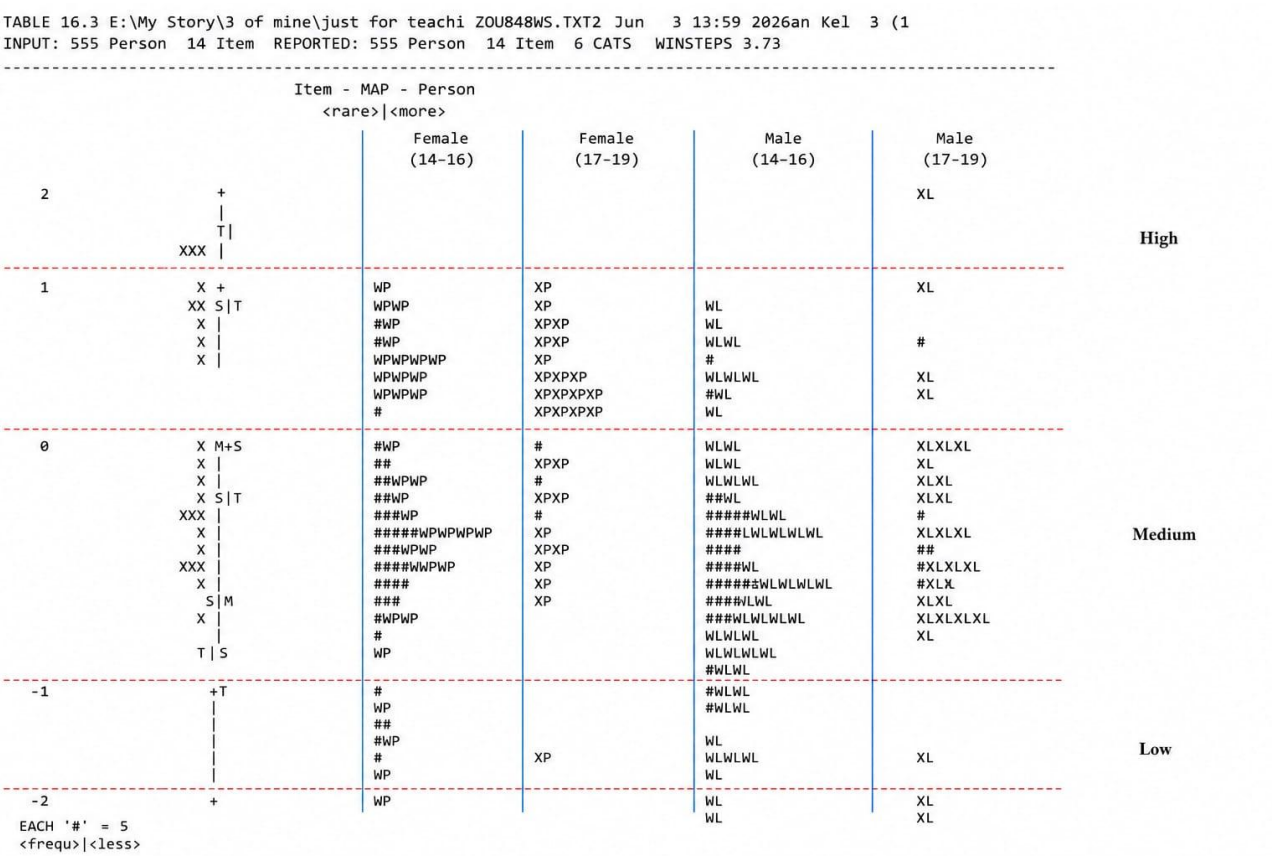

Figure 2. Wright Maps of Mathematical Literacy by Gender and Age

Based on the mapping, the Female (17–19) group showed the widest spread toward the high-ability end, followed by Male (17–19), while Male (14–16) had the most individuals in the low-ability category. This pattern suggests that age plays a greater role than gender in determining mathematical literacy ability levels, and that differences in mathematical literacy between male and female students exist but are influenced by various individual and contextual factors consistent with findings that male students tend to demonstrate stronger numeracy literacy performance, while female students show advantages in reading-related literacy tasks (Jamaesa, 2022; Rosida, 2023). Furthermore, to obtain a comprehensive overview of the alignment between respondents' ability levels and item difficulty levels across both instruments simultaneously, the combined Wright Map of the Adversity Quotient and mathematical literacy instruments is presented in Figure 3 below.

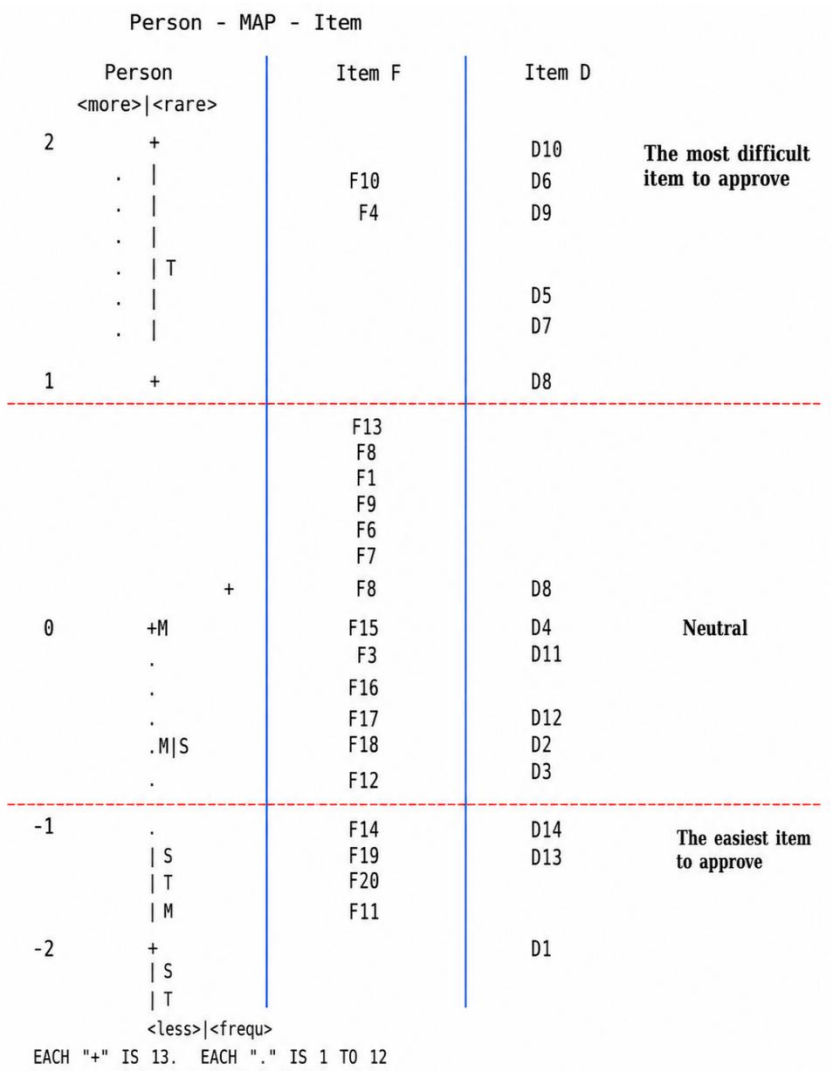

Figure 3. Wright Map of the Adversity Quotient and Mathematical literacy Instrument (Overall Item–Person Map)

Based on the figure 3 Mathematical literacy instrument contains a greater number of difficult items than the AQ instrument thats because many students experience difficulties in solving context-based mathematical literacy tasks (OECD, 2023). While most AQ items are concentrated within the neutral difficulty level, suggesting that the instrument is generally well targeted to respondents' abilities , and In contrast, the Mathematical Literacy instrument shows an equal number of items in the difficult and neutral categories, indicating a balanced distribution of item difficulty across these two levels, Furthermore, only a small number of items from both the AQ and Mathematical Literacy instruments fall into the easy category, suggesting that relatively few items are overly easy for respondents to answer. Ira Suri (2025) reported that mathematical literacy tasks are more demanding than routine mathematics problems because they require students to interpret real-world situations, construct mathematical models, and apply appropriate mathematical concepts before obtaining a solution. Consequently, many students still struggle with mathematical literacy tasks compared with conventional mathematics exercises.

DISCUSSION

First, the findings indicate that students' Adversity Quotient (AQ) varied according to educational, age, and gender, suggesting that AQ develops progressively through accumulated academic experience (Gradini & Noviani, 2025; Shengyao et al., 2024). Male students also tended to have higher AQ than female students, which may be related to greater mathematics anxiety among female students (A. Faradillah & Wulandari, 2021). Furthermore, students with higher AQ and

mathematical literacy performance were more persistent when facing contextual problems, while low-AQ students tended to disengage more easily consistent with prior studies on the relationship between resilience and mathematical literacy (Puspita et al., 2023; Ramadhani et al., 2023).

In Addition, AQ in this study shows that male students generally demonstrated higher Adversity Quotient (AQ) levels than female students, as reflected by the greater concentration of male respondents at the medium and high ability levels. Across age groups, female students aged 14–16 and 17–19 showed relatively similar distributions, suggesting no substantial difference in AQ between the two age categories. In contrast, male students aged 17–19 exhibited a noticeably higher concentration at the upper ability levels than males aged 14–16, indicating that older male students tended to demonstrate stronger resilience in dealing with academic challenges.

Futhermore this studi reveals that most AQ items were concentrated within the neutral difficulty level, indicating that the instrument is generally well targeted to the ability range of the respondents. However, the map also shows a notable shortage of items at the easy difficulty level, meaning that the instrument lacks sufficient items to precisely measure students who fall at the lower end of the AQ spectrum. This person item mismatch reduces measurement accuracy for low AQ students, as they have too few items that appropriately correspond to their ability level (A. Faradillah & Adlina, 2021). Meanwhile, the item fit analysis in Table 2 identified several AQ items including F4, F5, F10, F11, and F20 as misfitting the Rasch model because not fulfill the the minimum criteria, where items from different dimensions may produce inconsistent response patterns that violate the unidimensionality assumption of the Rasch model (Adnan et al., 2022). Therefore, future development of the AQ instrument should include additional easy-level items and revise misfitting items to improve measurement precision across the full range of students' adversity resilience.

And than this study shows the Mathematical Literacy instrument contains a relatively high proportion of difficult items. The items are distributed across difficulty levels, with an equal number of items classified as difficult and neutral, while only a few items fall into the easy category. This indicates that the instrument provides a balanced range of item difficulty but emphasizes more challenging tasks. The predominance of difficult items may be explained by the nature of mathematical literacy tasks, which require students to interpret real-world contexts, formulate mathematical models, and apply appropriate mathematical concepts to solve problems. These demands make mathematical literacy items more complex than routine mathematics exercises. As a result, many students experience difficulties in solving mathematical literacy tasks, leading to a greater concentration of items in the difficult category and relatively few items being considered easy.

CONCLUSION

This study has addressed all of the research objectives outlined in the introduction. The Rasch Model analysis revealed that students' mathematical literacy was still relatively limited, as indicated by the greater proportion of difficult items compared to easy ones, whereas students' AQ tended to be higher among senior high school students, older students, and male students. In terms of item difficulty, the mathematical literacy instrument contained more difficult items than the AQ instrument, while most AQ items were concentrated at the neutral difficulty level, indicating that the AQ instrument is generally well targeted to respondents' abilities but lacks easier items. The item fit analysis further showed that eleven of fourteen mathematical literacy items and ten of twenty AQ items fit the Rasch model, while items D1, D13, and D14 in the mathematical literacy instrument, along with several AQ items associated with the multidimensional CO2RE construct, were identified as misfitting. Based on these findings, it is recommended that the misfitting items be revised to improve clarity and unidimensionality, and that additional easy-level items, particularly for the AQ instrument, be developed in order to produce more valid and reliable instruments for measuring students' mathematical literacy and adversity quotient in future studies.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to Universitas Muhammadiyah Prof. DR. HAMKA for providing support and facilities for this research. We also thank the lecturer of the Evaluation of Learning and Learning Outcomes course, the expert validators, the English teacher validator, and the mathematics teacher validator for their valuable guidance, suggestions, and feedback. Finally, we appreciate all colleagues and parties who contributed to the completion of this research and article.

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