



VALIDATION OF INSTRUMENT TO MEASURE HIGH SCHOOL STUDENT ATTITUDE TOWARD STEM: RASCH ANALYSIS

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Abstract

The rapid advancement of science and technology has increased the importance of fostering positive student attitudes toward STEM education, as these attitudes play a crucial role in shaping future learning and career pathways. This study aims to validate an instrument designed to measure high school students' attitudes toward STEM using the Rasch measurement model. A quantitative cross-sectional design was employed, involving 128 students from two schools in Mataram selected through convenience sampling. The instrument, adapted from previous research, underwent translation, back-translation, and expert validation to ensure content and construct appropriateness. Data were collected through a face-to-face survey and analyzed using Winsteps software. The results indicate high reliability, with person reliability of 0.95 and item reliability of 0.91, supported by strong separation indices and a Cronbach's alpha of 0.96. Most items demonstrated acceptable fit statistics, although a few items showed misfit and require revision. The Wright map revealed that students generally exhibit high attitudes toward STEM, with some limitations in item targeting at higher ability levels. Unidimensionality analysis confirmed that the instrument measures a single dominant construct. These findings suggest that the instrument is a valid and reliable tool for assessing students' attitudes toward STEM in educational contexts.

Keywords

STEM Attitudes, Rasch Analysis, Instrument Validation, High School Students, Psychometric Properties

Abstrak

Perkembangan pesat ilmu pengetahuan dan teknologi telah meningkatkan pentingnya menumbuhkan sikap positif siswa terhadap pendidikan STEM, karena sikap tersebut memainkan peran penting dalam membentuk jalur pembelajaran dan karier di masa depan. Penelitian ini bertujuan untuk memvalidasi instrumen yang dirancang untuk mengukur sikap siswa sekolah menengah terhadap STEM menggunakan model pengukuran Rasch. Desain penelitian kuantitatif dengan pendekatan cross-sectional digunakan, melibatkan 128 siswa dari dua sekolah di Mataram yang dipilih melalui teknik convenience sampling. Instrumen yang diadaptasi dari penelitian sebelumnya telah melalui proses penerjemahan, back-translation, serta validasi oleh para ahli untuk memastikan kesesuaian isi dan konstruk. Data dikumpulkan melalui survei tatap muka dan dianalisis menggunakan perangkat lunak Winsteps. Hasil penelitian menunjukkan reliabilitas yang tinggi, dengan reliabilitas responden sebesar 0,95 dan reliabilitas item sebesar 0,91, yang didukung oleh indeks pemisahan yang kuat serta nilai

Cronbach's alpha sebesar 0,96. Sebagian besar item menunjukkan statistik kecocokan yang dapat diterima, meskipun beberapa item menunjukkan ketidaksesuaian (misfit) dan memerlukan revisi. Peta Wright mengungkapkan bahwa siswa umumnya memiliki sikap yang tinggi terhadap STEM, meskipun terdapat keterbatasan dalam penargetan item pada tingkat kemampuan yang lebih tinggi. Analisis unidimensionalitas mengonfirmasi bahwa instrumen mengukur satu konstruk dominan. Temuan ini menunjukkan bahwa instrumen tersebut merupakan alat yang valid dan reliabel untuk menilai sikap siswa terhadap STEM dalam konteks pendidikan.

Kata kunci: Sikap STEM, Analisis Rasch, Validasi Instrumen, Siswa Sekolah Menengah, Sifat Psikometrik



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INTRODUCTION

The development of science, technology, engineering, and mathematics (STEM) has become a central driver of national progress across economic, social, and technological sectors (Karthikeyan, 2026; Şeker, 2026). Countries with strong STEM capacities tend to demonstrate higher levels of innovation, productivity, and global competitiveness. STEM fields contribute to advancements in industry, healthcare, infrastructure, environmental sustainability, and digital transformation. Rapid technological changes, including artificial intelligence, automation, and data science, increasingly shape the future workforce and require individuals equipped with interdisciplinary STEM competencies (Chiu, Li, Ding, Hallström, & Koretsky, 2025). Educational systems play a critical role in preparing students with the knowledge and skills needed to engage in these fields. The integration of STEM education also supports problem-solving, critical thinking, and creativity, which are essential for addressing complex global challenges. As economies transition toward knowledge-based structures, the demand for a STEM-literate population continues to grow across both developed and developing countries (Jamali, Ale Ebrahim, & Jamali, 2023).

Many countries have initiated strategic efforts to encourage younger generations to engage with STEM disciplines. Governments and educational institutions implement policies that integrate STEM into school curricula, promote hands-on learning, and provide access to modern technologies. Programs such as STEM camps, robotics competitions, coding workshops, and science fairs are widely organized to increase student interest and participation. Scholarships and career pathways in STEM-related fields are also introduced to attract students from diverse backgrounds (Judson, 2025; Ma, Li, & Dong, 2025). In countries like the United States, the United Kingdom, and Singapore, national frameworks emphasize early exposure to STEM through inquiry-based and project-based learning approaches. These initiatives aim to build foundational skills and foster positive learning experiences that can influence long-term educational and career choices among students (Effendi, Sriyanti, Wiyono, Marlina, & Rosdiana, 2025).

In the context of Indonesia, similar initiatives have been developed to strengthen STEM education among young learners. The government has introduced curriculum reforms that incorporate elements of science, technology, engineering, and mathematics into integrated learning

activities (Indriyanti, Qudratuddarsi, Intan, & Hebrriawan, 2026; Riady, 2025). Programs such as digital literacy campaigns, teacher training, and the use of educational technology platforms have been promoted to support STEM learning in schools. Collaboration between educational institutions, industries, and international organizations has also been encouraged to provide students with exposure to real-world applications of STEM. Extracurricular activities, including science Olympiads and innovation competitions, are frequently organized to stimulate student engagement. Efforts are also made to expand access to STEM education in rural and underserved areas through infrastructure development and online learning resources that connect students with broader learning opportunities (Barus, Ringo, Sitepu, & Siallagan, 2025; Rahmi, Syahmani, Mahardika, Suyidno, & Suwandy, 2025).

Understanding the attitudes of Indonesian high school students toward STEM is essential for examining how they perceive, value, and engage with these fields during a critical stage of educational development. Attitude plays a significant role in shaping students' motivation, interest, and willingness to pursue further studies or careers related to STEM (Cong, Thuy, Kim, Viet, & Kim, 2025; Potvin, Lefebvre, Houle, Hasni, & Ahr, 2026; Manassero-Mas & Vázquez-Alonso, 2025). Differences in background, learning experiences, and exposure to STEM-related activities may influence how students respond to these subjects. In Indonesia, variations in educational resources and teaching practices across regions may also affect student attitudes. Identifying these attitudes provides insight into potential barriers and opportunities within STEM education. It also allows educators and policymakers to better align instructional strategies with student needs and preferences. Measuring student attitudes can reveal patterns that are not always visible through academic performance alone (Vaiopoulou, Papagiannopoulou, & Stamovlasis, 2024).

The process of instrument validation is essential to ensure that a measurement tool accurately captures the intended construct. In educational research, instruments used to assess student attitudes must demonstrate validity and reliability before being applied in broader contexts. Validation involves examining whether the items within an instrument effectively represent the theoretical framework and whether they function consistently across different groups of respondents (Muaziyah, Zainal, Agni, Supriyadi, & Isnawati, 2025). Without proper validation, the results obtained from the instrument may lead to misinterpretation or inaccurate conclusions. Statistical approaches, including Rasch analysis, provide a rigorous method for evaluating item quality, person responses, and measurement properties within an instrument. This process supports the development of a scale that can produce meaningful and interpretable data related to student attitudes toward STEM (Tsai, Ting, & Chu, 2025).

Instrument validation also allows researchers to refine measurement tools by identifying items that do not perform well or align with the underlying construct. Through techniques such as item fit analysis, reliability estimation, and dimensionality assessment, researchers can improve the precision and consistency of the instrument (Amatan, Han, & Pang, 2025; Gavrilas, & Kotsis, 2025). Rasch analysis, in particular, enables the transformation of ordinal data into interval-level measurements, which enhances the quality of statistical interpretation. It also provides information about item difficulty and respondent ability, allowing for a more nuanced understanding of the data. A validated instrument can be used confidently in different educational settings and populations, supporting comparative studies and longitudinal research. The availability of a well-validated instrument contributes to more accurate assessments of student attitudes and supports evidence-based decision-making in STEM education contexts.

RESEARCH METHOD

Research Design

This study employs a quantitative cross-sectional research design to validate an instrument measuring high school students' attitudes toward STEM using Rasch analysis. Data are collected at a single point in time by directly administering the questionnaire to students without any intervention or treatment. The participants consist of high school students selected through appropriate sampling techniques to represent the target population. The instrument includes structured items designed to capture various dimensions of attitudes toward STEM, such as interest, motivation, and perceived relevance (Adam, Qudratuddarsi, Tari, & Putri, 2024; Noviana, Putra, Cinthami, & Qudratuddarsi, 2026). Responses are recorded using a Likert scale format and analyzed using the Rasch measurement model to evaluate item fit, reliability, person-item distribution, and unidimensionality. This approach allows for examining the psychometric properties of the instrument, ensuring that it functions consistently across respondents and accurately measures the intended construct within the given educational context.

Research Subject

The research subjects in this study consist of 128 high school students from two selected schools in Mataram. The participants were chosen using a convenience sampling technique, allowing the researcher to access readily available students who met the study criteria. These students represent a range of academic backgrounds and grade levels, providing variability in responses toward STEM attitudes. The inclusion of participants from two different schools helps capture diverse perspectives within the same geographic context. All respondents were actively enrolled at the time of data collection and voluntarily participated in completing the instrument (Jumriani, Qudratuddarsi, Rahmah, Ningthias, & Indriyanti, 2025; Qudratuddarsi, & Meivawati, 2025). Prior to data collection, necessary permissions were obtained from school authorities, and students were informed about the purpose of the study. Their responses were collected anonymously to ensure confidentiality and encourage honest answers, thereby supporting the accuracy and reliability of the data gathered for the Rasch analysis procedure used in this study overall.

Instruments

The instrument used in this study to measure high school students' attitudes toward STEM was adopted from Benek and Akcay (2019), which has been previously developed and tested in a related educational context. The instrument consists of a set of structured items designed to capture multiple dimensions of students' attitudes toward STEM, including interest, engagement, and perceived value. To ensure its suitability for the current study, the instrument underwent a rigorous adaptation process. First, the original version was translated into the target language and then back translated into the original language to maintain semantic equivalence and clarity of meaning. Additionally, the content validity of the instrument was evaluated by three qualified experts in the fields of education and measurement, who reviewed each item for relevance, clarity, and cultural appropriateness. Their feedback was used to refine the wording and structure of the items before the instrument was administered to participants in the data collection process.

Data Collection Procedure

The data collection procedure in this study was conducted through a face-to-face approach to ensure that students clearly understood the purpose and themes of the research. Prior to administering the instrument, the researcher coordinated with school authorities to obtain permission and schedule appropriate times for data collection (Rizal, & Genisa, 2024). During the sessions, students were gathered in their classrooms and provided with a brief explanation of the study objectives and instructions on how to complete the questionnaire. The researcher remained present throughout the process to clarify any questions and ensure that students responded appropriately to each item. This direct interaction helped minimize misunderstandings and increased the accuracy of responses. Students completed the instrument individually within a specified time frame, and all responses were collected immediately after completion to maintain data integrity and completeness for subsequent Rasch analysis procedures (Hidayat, Qudratuddarsi, Ayub, & Latif, 2025).

Data Analysis

Data analysis for validating an instrument measuring high school students' attitudes toward STEM using the Rasch model focuses on examining item-person interactions and measurement quality. The Wright map (person-item map) is used to visualize the distribution of student abilities and item difficulties on the same logit scale, allowing researchers to assess whether items appropriately target the range of student attitudes. Item fit statistics, including infit and outfit mean square values, are evaluated to determine how well each item conforms to Rasch model expectations; items with values typically between 0.5 and 1.5 are considered productive for measurement, while misfitting items may indicate ambiguity or multidimensionality. Reliability analysis involves examining person reliability and item reliability indices, as well as separation indices, to assess the consistency and replicability of the instrument in distinguishing between different levels of student attitudes. Unidimensionality is tested using principal component analysis of residuals (PCAR), where the proportion of variance explained by the Rasch dimension and the size of unexplained contrasts are analyzed to confirm that the instrument measures a single underlying construct of STEM attitude.

RESULTS AND DISCUSSION

Reliability

Reliability refers to the consistency of an instrument in measuring a construct across respondents, indicating the extent to which the results are stable and reproducible. In Rasch analysis, reliability is examined through person and item reliability indices, which reflect the consistency of respondents' measures and item difficulty hierarchy, respectively. Separation indices complement reliability by indicating how well the instrument distinguishes between different levels of respondents or item difficulties, with higher values suggesting better differentiation. Cronbach's alpha is also used to assess internal consistency, where values above 0.70 are generally considered acceptable. Additionally, the chi-square statistic evaluates the overall model fit by comparing observed and expected responses, with significant values suggesting variability that may indicate meaningful measurement distinctions among respondents and items.

Based on Table 1, the person reliability value of 0.95 indicates excellent consistency in distinguishing students' attitudes toward STEM, supported by a high person separation index of 4.15, which suggests that respondents can be classified into several distinct levels. The item reliability

value of 0.91 demonstrates strong stability in the hierarchy of item difficulty, while the item separation index of 3.26 indicates that the items are well distributed across varying levels of difficulty. The Cronbach's alpha value of 0.96 further confirms very high internal consistency among the instrument items. The chi-square value of 7336.65 with 3833 degrees of freedom reflects a significant dispersion in the data, indicating that the model effectively captures variation in both person abilities and item characteristics within the measurement framework.

Table 1. Reliability and Separation

	Value
Person Reliability	0.95
Person Separation	4.15
Item Reliability	0.91
Item Separation	3.26
Cronbach alpha	0.96
Chi-square	7336.65 with df 3833

Wright Map

A Wright map, also known as a person–item map, is a visual output of Rasch analysis that places both respondents and items on the same logit scale to examine how well the instrument targets the sample. The map typically centers at 0.00 logits, representing the average item difficulty, and ideally the mean of person ability should be close to this value for good alignment. Items above the mean are more difficult to endorse, while those below are easier, and respondents located higher on the scale indicate stronger attitudes toward STEM. Based on Figure 1, the person mean is approximately +1.20 logits, indicating that, on average, students exhibit relatively high attitudes compared to item difficulty. The items are distributed from around -2.50 to +2.30 logits, while person abilities range from about -1.80 to +3.50 logits, showing a wider spread among respondents. Some clustering of items appears near the center, with slight gaps at higher logit levels, suggesting limited item coverage for very high-attitude students.

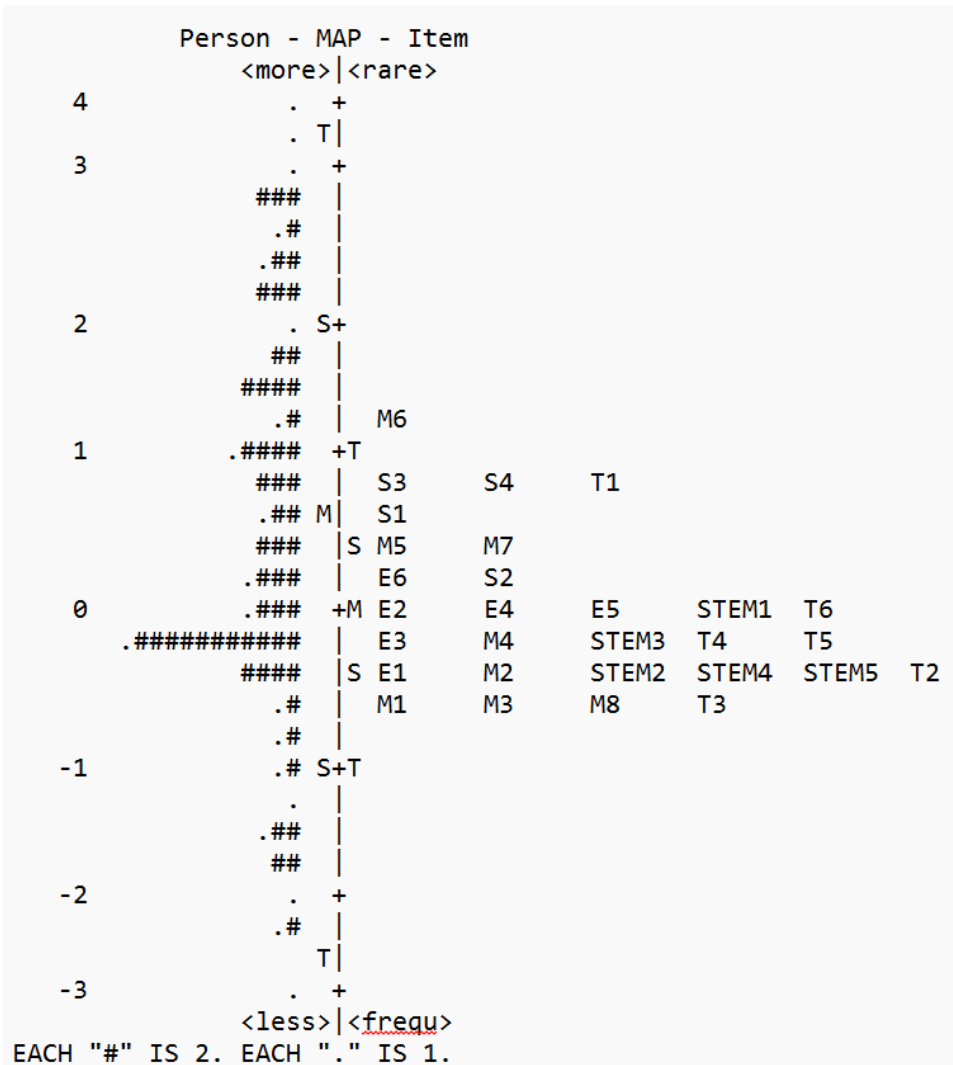


Figure 1. Wright Map

Fit Statistics

Fit statistics in Rasch analysis are used to evaluate how well each item conforms to the expectations of the measurement model, indicating whether items function consistently in measuring the intended construct. The most commonly used indices are Infit and Outfit Mean Square (MNSQ) and their standardized values (ZSTD). Acceptable MNSQ values generally range from 0.5 to 1.5, where values above 1.5 indicate noise or unpredictability, and values below 0.5 suggest redundancy. ZSTD values are expected to fall between -2.0 and +2.0. Additionally, point-measure correlation (Pt Mea Corr) reflects the relationship between item scores and overall measures, with positive values above 0.3 indicating good discrimination. These indicators collectively help determine whether items are suitable for inclusion in the instrument.

Based on the data, most items fall within acceptable fit ranges, such as S2, T2, and M1, indicating good model conformity. However, items T1 (Infit 1.97; Outfit 1.99) and M6 (Infit 1.70; Outfit 1.93) exceed the upper threshold, suggesting misfit and potential inconsistency in measuring the construct. Items S3 and S4 also show slightly elevated values above 1.3, indicating moderate misfit. Conversely, several items such as E5, STEM1, and STEM4 show low MNSQ values below 0.7, suggesting overfit or redundancy. All items demonstrate positive Pt Mea Corr values ranging

from 0.38 to 0.81, indicating acceptable discrimination, although T1 shows the lowest correlation and may require further review or revision.

Table 2. Item Fit Statistics

No	Item	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD	Pt Mea Corr
1	S1	0.77	-1.9	0.76	-2.0	0.67
2	S2	0.95	-0.4	0.95	-0.3	0.69
3	S3	1.3	2.3	1.36	2.6	0.57
4	S4	1.35	2.6	1.34	2.4	0.59
5	T1	1.97	6.2	1.99	6.1	0.38
6	T2	1.01	0.1	1.03	0.3	0.67
7	T3	0.96	-0.3	0.97	-0.2	0.64
8	T4	1.05	0.4	1.03	0.3	0.67
9	T5	0.84	-1.3	0.83	-1.4	0.74
10	T6	1.01	0.1	0.96	-0.3	0.66
11	E1	1.21	1.7	1.2	1.6	0.66
12	E2	0.81	-1.6	0.82	-1.5	0.74
13	E3	0.9	-0.8	0.89	-0.9	0.71
14	E4	0.75	-2.2	0.75	-2.1	0.76
15	E5	0.68	-2.8	0.68	-2.8	0.81
16	E6	0.73	-2.3	0.74	-2.1	0.7
17	M1	1.09	0.8	1.07	0.6	0.7
18	M2	0.83	-1.4	0.83	-1.4	0.72
19	M3	0.8	-1.7	0.77	-2.0	0.72
20	M4	0.81	-1.5	0.84	-1.3	0.74
21	M5	0.96	-0.2	0.98	-0.1	0.62
22	M6	1.7	4.9	1.93	5.9	0.51
23	M7	1.05	0.5	1.1	0.8	0.7
24	M8	1.1	0.9	1.11	0.9	0.7
25	STEM1	0.68	-2.8	0.68	-2.7	0.75
26	STEM2	0.91	-0.7	0.93	-0.5	0.68
27	STEM3	1.06	0.5	1.01	0.1	0.61
28	STEM4	0.7	-2.6	0.7	-2.7	0.77
29	STEM5	0.71	-2.5	0.72	-2.5	0.8

Unidimensionality

Unidimensionality in Rasch analysis refers to the extent to which an instrument measures a single underlying construct, ensuring that all items contribute to one dominant latent trait. This assumption is essential for valid measurement, as it confirms that the scale is not influenced by multiple unrelated dimensions. Unidimensionality is typically evaluated using Principal Component Analysis (PCA) of standardized residuals. A commonly accepted standard is that the raw variance explained by measures should exceed 40%, indicating a strong primary dimension. Additionally, the unexplained variance in the first contrast should ideally be small, often less than 15% or with an eigenvalue below 2.0, to confirm that no secondary dominant dimension exists within the data structure.

Based on Table 3, the total raw variance in observations is 56.0 (100%), with 27.0 (48.2%) explained by the Rasch measures, which exceeds the recommended 40% threshold, indicating a strong primary construct. Of this, person measures account for 17.3 (30.9%) and item measures contribute 9.7 (17.3%), showing that both respondent ability and item difficulty meaningfully contribute to the overall variance. The alignment between empirical (48.2%) and modeled (48.2%)

variance further supports the consistency of the measurement model. These results suggest that the instrument demonstrates adequate unidimensionality, as a substantial proportion of variance is explained by a single dominant factor representing students' attitudes toward STEM.

Table 3. Standardized Residual Variance

	Empirical (Eigenvalue)	Empirical (%)	Modeled (%)
Total raw variance in observations	56.0	100	100
Raw variance explained by measures	27.0	48.2	48.2
Raw variance explained by persons	17.3	30.9	30.9
Raw variance explained by items	9.7	17.3	17.3

The findings demonstrate that the instrument exhibits strong psychometric properties in measuring students' attitudes toward STEM, as indicated by high reliability indices and satisfactory separation values. The person reliability (0.95) and item reliability (0.91) confirm that the instrument consistently differentiates both respondent abilities and item difficulty levels. The Wright map further reveals that students generally possess relatively high attitudes toward STEM, although the distribution suggests limited item targeting for respondents at the highest ability levels. In terms of fit statistics, most items conform well to the Rasch model, indicating that they effectively represent the intended construct. However, a few misfitting items, such as T1 and M6, suggest potential ambiguity or inconsistency that may affect measurement precision. The unidimensionality analysis supports the validity of the instrument, as a substantial proportion of variance is explained by a single dominant construct. These results collectively indicate that the instrument is robust for assessing STEM attitudes while highlighting areas for refinement.

Several limitations should be acknowledged in this study. First, the use of a convenience sampling technique with participants drawn from only two schools in a single geographic area may limit the generalizability of the findings to broader populations. Differences in educational environments, socio-economic backgrounds, and access to STEM resources across regions may influence students' attitudes in ways not captured in this sample. Second, the cross-sectional design restricts the ability to observe changes in attitudes over time, making it difficult to assess developmental trends or causal relationships. Third, although most items demonstrated acceptable fit, the presence of misfitting and overfitting items indicates that some aspects of the instrument may require revision for improved precision. Additionally, reliance on self-reported data may introduce response bias, as students might provide socially desirable answers rather than reflecting their true perceptions.

The results of this study offer several important implications for educational research and practice. The validated instrument can serve as a reliable tool for assessing students' attitudes toward STEM in various educational contexts, supporting both classroom evaluation and large-scale studies. Educators may use the findings to better understand student engagement, motivation, and perceptions of STEM, allowing for more targeted instructional strategies that enhance learning experiences. The identification of item misfit also provides guidance for refining assessment tools to improve measurement accuracy. From a policy perspective, the instrument can inform decision-making related to curriculum development, particularly in designing programs that foster positive attitudes toward STEM disciplines. Furthermore, the evidence of strong unidimensionality supports

the theoretical coherence of the construct, enabling its integration into further modeling approaches, such as examining relationships between attitudes and academic outcomes or participation in STEM-related pathways.

CONCLUSION

This study confirms that the instrument used to measure high school students' attitudes toward STEM demonstrates strong validity and reliability based on Rasch analysis. High person and item reliability indices indicate consistent measurement performance, while separation indices show the instrument's ability to distinguish varying levels of student attitudes and item difficulty. The Wright map reveals that students generally exhibit positive attitudes toward STEM, although some gaps in item targeting remain for higher-ability respondents. Most items fit well within the Rasch model, supporting their appropriateness in representing the intended construct, despite a few items requiring refinement due to misfit or redundancy. The unidimensionality analysis further supports that the instrument measures a single dominant construct, ensuring conceptual clarity. Overall, the instrument provides a robust measurement framework for assessing STEM attitudes and offers a reliable basis for further educational research and evaluation in diverse learning contexts.

Future research is encouraged to expand the sample size and include participants from diverse regions and educational settings to enhance the generalizability of the findings. Longitudinal studies may also be conducted to examine changes in students' attitudes toward STEM over time and to identify potential causal relationships with learning outcomes. Refinement of misfitting and overfitting items is recommended to improve the precision and balance of the instrument, particularly in capturing higher levels of student attitudes. Researchers may also integrate this validated instrument with other analytical approaches, such as Structural Equation Modeling, to explore relationships between attitudes, motivation, and academic achievement. Additionally, incorporating qualitative methods could provide deeper insights into students' perceptions and experiences, thereby enriching the interpretation of quantitative results and supporting more comprehensive understanding in STEM education research contexts.

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