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Rasch Validation of Instrument Measuring Gen-Z Science, Technology, Engineering, and Mathematics (STEM) Application in Teaching during the Pandemic

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Abstract. The impact of the Covid-19 pandemic has had a far-reaching effect on higher education institutions, and individual student assessments have garnered much attention during the pandemic. This study aimed to validate Science, Technology, Engineering, and Mathematics (STEM) application instruments using the Rasch analysis employing Winsteps version 3.73. A survey was conducted with 201 respondents from two provinces in Indonesia. The students were selected by convenience sampling and answered the adopted STEM application instrument. The STEM application instruments were adapted, and these were divided into seven sub-constructs derived from STEM disciplines. Rasch Modelling was employed for data analysis using Winsteps version 3.7.3 to analyse reliability, separation, item fit statistics, unidimensionality, and rating scale calibration. Each sub-construct

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fulfilled a minimum of 0.65 for Cronbach alpha, item, and person reliability, and most of them had more than 1.5 person and item separation. In general, each item had a good score of the mean square, Z-tolerated standard, and point measure correlation, indicating fulfilment of the Rasch measurement model. The analysis also showed unidimensionality assumption and an excellent rating scale. This study contributed to the body of STEM knowledge by using Rasch Modelling to test the validity and reliability of STEM application instruments.

Keywords: COVID-19 pandemic; Gen-Z; STEM education; higher education; Rasch model

1. Introduction

A systemic review has shown that Science, Technology, Engineering, and Mathematics (STEM) education research is growing in importance on a global scale, and the identity of STEM education publications is obvious in the realms of politics, economics, and education (Li et al., 2020a). The importance of STEM is also evident in the substantial amount of funding for STEM education research, which has required research collaboration (Carlisle & Weaver, 2018; Li et al., 2020). Li et al. (2020b) found that the number of projects with several principal investigators has risen over time, and STEM education projects have become increasingly collaborative. In Indonesia, as is worldwide, implementation of STEM education is a hot topic among educational researchers. The trend assumes that STEM education is crucial in educating future scientists and engineers to meet the rapid development of technology (Geng et al., 2019). Similarly, STEM education is rapidly being adopted by educational research to increase employment and career opportunities, community STEM literacy (Zouda, 2018), and to acquire key skills and abilities that will be beneficial personally and professionally (Garry et al., 2020). Salzman and Benderly (2019), for example, point out that STEM education produces a large number of students who can fill STEM job openings.

People who were born after 1995, known as Generation Z (Gen-Z), were the first to be born into a globally (internet) connected world. Their birth aligns with the beginning of the worldwide web's appearance (Chicca & Shellenbarger, 2018), and the beginning of the digital and internet era. As digital natives, they live and breathe technology, they are quick decision-makers and are highly connected (Cilliers, 2017). Owing to their intense interaction with technology, Gen-Z go by many other appellations: post-millennial, the Facebook generation, switcher, dotcom children, net-generation, connection generation, digital-generation, and responsibility-generation (Csobanka, 2016). Other terms include the N generation (for net), the D generation (for digital), the V generation (for viral), and the Google generation (Poláková & Klmová, 2019). Generation Z adults differ from other generations in that they are more connected to the digital and electronic world, which they identify as digital and technology-centric (Sing & Dangmei, 2016). Technology has been integrated into their daily lives and tends to influence their thinking patterns (Polakova & Klimova, 2019). Generation Z has mostly been educated using technology in their daily lives and academic endeavours (Talmon, 2019), and their learning characteristics are unsuitable for traditional methods of teaching (Szymkowiak et al., 2021). The challenges of building a STEM education for Gen-Z have been explored, but to date, the role of Gen-Z as teachers is not as comprehensively discussed in the literature as is that of their closest predecessors (millennial teachers).

Given their under-representation in STEM fields, it is apparent that persuading Gen-Z to choose STEM careers is a major task. This under-representation is true of most of Indonesia's population. Salzman and Benderly (2019) found that the STEM workforce constitutes a tiny percentage of the overall student population, accounting for around only 5% of K-12 students and 8% to 10% of the annual supply of university graduates. In Australia, for instance, Timms et al. (2018) found that elementary and high school pupils' interest in STEM subjects is waning, as is their performance. The same is happening in the Malaysian context. Using a longitudinal study, Mohd Shahali et al. (2019) showed that secondary school students' (13–14 years old) interests did not improve significantly after the programme (Bitara-STEM: Science of Smart Communities Program; Bitara-STEM) was conducted. Senior high schools in Indonesia revealed diverse beliefs and interests (Suwono et al., 2019): male students were more interested in engineering than female students were in biology. Mohd Shahali et al. (2019) emphasised that the quality of instruction and learning students received in the course was a contributing factor to their lack of interest in STEM education, making it critical to investigate and create an instrument for instructors to evaluate STEM teaching.

The implementation of STEM education during the COVID-19 pandemic presented new challenges. According to Bakker et al. (2021), during a pandemic it is critical to research learning and teaching of mathematics in a variety of situations, including professional development, new goals, curriculum, assessment, and teaching methods. Individual student assessments have garnered much attention, but the review of the curriculum has been neglected. In STEM settings, unfavourable environmental circumstances, time management concerns, and a lack of expertise and experience in lesson planning were among the difficulties instructors encountered (Aykan & Yıldırım, 2022) during the pandemic.

Given the importance of teaching quality and its influence on students' interests, understanding how to use the most appropriate valid instrument for the Gen-Z generation is important. We used the instrument proposed by Wahono and Chang (2019b), with its seven sub-domains, to assess teachers' use of STEM instruction during the COVID-19 pandemic. This instrument used a limited sample (secondary school science teachers) and tested only the exploratory factor analysis (EFA). A large number of samples and advanced analysis were utilised to ensure the quality of the instrument and fit to sample, which are crucial. Many researchers have provided proof of the reliability and validity issues as they commonly adopt measurements from one cultural setting in another (Hidayat et l., 2018; Hidayat et al., 2021). Most prior studies, on the other hand, have focused on using the EFA and confirmatory factor analysis (CFA) to explore data on validity and reliability issues across a variety of cultural backgrounds. According to Clarke (2013), the variety of cultural foundations is becoming increasingly obvious.

This study aimed to validate STEM application instruments using the Rasch analysis. The Rasch analysis compensates for several of the shortcomings in previous studies of STEM application instruments (Wahono & Chang, 2019b), and it gives a more accurate model of the data than results based on means of coded items. For example, Wahono and Chang (2019b) only employed EFA to establish the validity of the scale and a reliability test. Rasch Analyses are anticipated to be at least as accurate as EFA, based on polychoric correlations. Rasch analysis will contribute to the pool of information in terms of validating teachers' applications toward STEM for Gen-Z in Indonesian classrooms during the COVID-19 pandemic. Using Rasch Analysis modelling will enhance the validity and reliability of the instrument, which is specifically analysed for its reliability, separation, item fit statistics, unidimensionality, and rating scale calibration. Some scholars argue that the Rasch model is used to determine and confirm deviant answers, such as person-fit statistics and item-fit statistics (Widhiarso & Sumintono, 2016), person answers and quality of tool (Bond & Fox, 2015), but concentrates only on item-fit statistics (Widhiarso & Sumintono, 2016). Since the current instrument employs the Likert-scale, it is important to transform the data to a ratio or interval scale to get a more reliable instrument. Alnahdi (2018) indicated that the transformation from raw numbers to interval values is easy to comprehend because each modification in one component has comparable weight across the scale.

The current study aimed to answer the following research question: Is the adopted STEM application instrument using the Rasch model valid and reliable in the Indonesian context? The present work contributes to the body of knowledge by applying Rasch Analysis modelling to test this instrument for Indonesians, in particular Gen-Z.

2. Literature Review

2.1 STEM Education

Several concepts of integrated Science, Technology, Engineering, and Mathematics (STEM) education have been offered, but no clear consensus has emerged. The term 'STEM' originated from the National Science Foundation in the late 1990s in the United States and is a broad term that encompasses both informal and formal education from pre-school to higher education (Shanahan et al., 2016). Several researchers have defined STEM as an interdisciplinary, applied strategy focused on real-world scenarios (Gomez & Albrecht, 2013; Peters-Burton et al., 2014). According to Sanders (2009), STEM refers to approaches that examine teaching and learning across or among any two or more of the STEM content areas and/or between a STEM topic and one or more other school subjects. Another scholar agreed with the concepts, but integrated STEM education is not limited to a combination of these fields as it can involve numerous classes (Stohlmann et al., 2012). Kelley and Knowles (2016) admit that integrated STEM education refers not only to a method of instructing students on the STEM topics of two or more STEM disciplines, but it is also a way of implementing authentic settings to improve student learning. In conclusion, STEM education is a method that examines teaching and learning in interdisciplinary STEM content areas (Kelley & Knowles, 2016), or involves numerous classes (Stohlmann et al., 2012) and focuses on real-world scenarios (Gomez & Albrecht, 2013; Kelley & Knowles, 2016; Peters-Burton et al., 2014) to improve students' understanding (Kelley & Knowles, 2016). The fundamental aims of STEM education are to increase students' scientific literacy and encourage them to seek scientific and technical vocations such as scientists, engineers, and mathematicians.

The definition of STEM education also depends on the level of discipline integration. English (2016) summarised discipline integration as multidisciplinary, interdisciplinary, and transdisciplinary approaches. From a multidisciplinary perspective, each field teaches concepts and abilities in its own way, yet they all have a fundamental theme. The concept of STEM integration proposed by Sanders (2009) seems to be similar to the multidisciplinary perspective, which focuses only on the combination of each STEM field. The goal of the interdisciplinary perspective is slightly different: to increase knowledge and abilities by learning closely related concepts and skills from two or more fields. This idea is in line with the definition of STEM combination suggested by Kelley and Knowles (2016), which focuses on enhancing student learning. Finally, the transdisciplinary perspective refers to the application of knowledge and abilities from two or more disciplines to real-world issues and projects that aid in shaping the learning experience. The STEM Task Force Report (2014) defined STEM integration from a transdisciplinary perspective; according to this report, STEM education is more than just a simple combination of the four domains; it includes actual, real-world, problem-based learning that connects the disciplines through coherent and proactive teaching and learning strategies. The interdisciplinary character of STEM is defined as a holistic strategy that integrates the separate disciplines so that learning becomes integrated, centred, purposeful, and relevant to learners. In other words, it is a continuous, dynamic, student-centred teaching and learning process. Despite these various perspectives, the key to equipping STEM teachers is to start with a conceptual knowledge of integrated STEM education by teaching essential learning frameworks, pedagogical techniques, and increasing awareness of current secondary STEM educational projects' research outcomes (Kelley & Knowles, 2016).

The idea of STEM has been extended to include the term 'art': Science, Technology, Engineering, Art, and Mathematics (STEAM) (Kim & Kim, 2016; Yakman & Lee, 2012). In a systematic review conducted by Perignat and Katz-Buonincontro (2019), STEAM education is described as an approach to engage students in STEM learning, promote students' creativity, or improve problem-solving abilities in real-world contexts. The two main aims of STEAM are, first, to raise interest in STEM topics and improve the skills needed for STEM professions, and to engage minority and female students in STEM courses; and second, to integrate domain-general abilities (e.g., skills in problem-solving and creativity) and encourage learners to experiment with and learn about new ways of thinking.

As with STEM learning, researchers distinguish between five techniques for combining STEAM disciplines: multi-disciplinary, interdisciplinary, transdisciplinary, cross-disciplinary, and arts-integration (Perignat & Katz-Buonincontro, 2019). Meeth (1978) has defined STEAM as a transdisciplinary approach to teaching and learning, and research has shown that STEAM activities help students learn in both cognitive and affective ways (Kang, 2019), enhancing their creativity (Wandari et al., 2018), engagement (Togou et al., 2020), and conceptual understanding, and minimising misconceptions (Ozkan & Umdu Topsakal, 2020). Hsiao and Su (2021) have revealed that combining STEAM education with Virtual Reality-assisted experience courses can assist learners in enhancing both their learning satisfaction and outcomes while also increasing their motivation to learn.

Science, Technology, Reading, Engineering, Art, and Mathematics (STREAM) was created to enhance 21st century abilities by leading to the development of metacognitive abilities (Padhmasari, 2016). STREAM education necessitates a student-centred approach: students might think about an issue, find appropriate techniques, and decide on a plan of action to solve a problem or complete a task. Students are required to develop, design, and solve issues (Badmus & Omosewo, 2018). However, STREAM education has been extended to different contexts, for example, incorporating STREAM into English Language Learners' (ELL) education can help ELL students grow and engage in STEM courses (Maarouf, 2019). Teachers have a comprehensive perspective and are enthusiastic about STREAM education (Nuangchalerm et., 2020). The importance of this study lies in the use of theory to establish the validity and reliability of skills measuring Gen-Z STEM applications during their teaching experiences. In previous studies (Parmin et al., 2020; Wahono & Chang, 2019a, 2019b), the selected instrument was validated using Classical Test Theory (CTT) by referring to reliability and EFA results. However, this study aimed to apply the Rasch measurement model to contribute to the body of knowledge. In many fields, previous researchers (i.e., Gocen & Sen, 2021; Hidayat et al., 2021; Jin et al., 2020; Sen & Gocen, 2021) have shown that applying CTT and Rasch models are appropriate strategies for finding well-validated instruments. The Rasch model can supplement CTT by providing more detailed analysis than just the relationship between an item and a latent factor (DiStefano et al., 2019; Rahayu et al., 2020; Rahayu et al., 2021). Figure 1 provides the conceptual framework for the current work employing Rasch analysis.

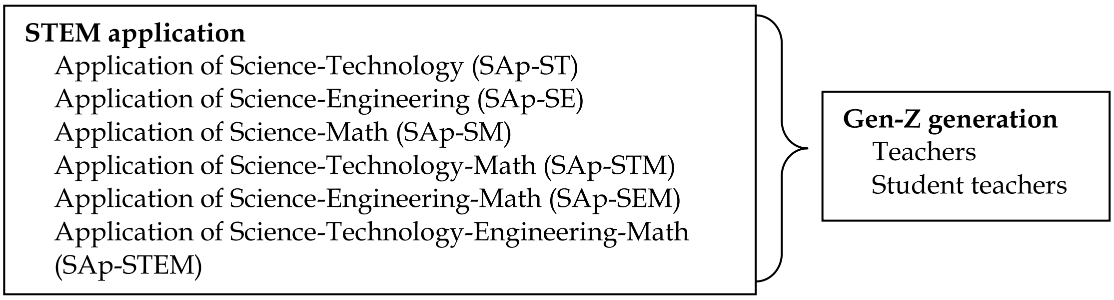

Figure 1: Conceptual framework

3. Methodology

3.1 Research Design

This study is a survey study (Creswell, 2014) for collecting data related to the Gen-Z application of integrating STEM fields. The survey method can be conducted on a large sample, and the results can be generalised to the population (Chua, 2020). The population in this research was the Indonesian Gen-Z generation. The survey was created to evaluate Gen-Z applications for integrating STEM fields because the study has the potential to enlighten, explain, and help us understand (Cole et al., 2019) a variety of applications for integrating STEM. The current work used the survey method to examine the reliability and validity of the application of STEM by Gen-Z. A convenience sampling strategy (Creswell, 2012) was used for its accessibility and availability (Anderson & Mittal, 2000), and respondents were asked to take an online survey. The researcher elected to use a convenience sampling strategy for its easy access to Gen-Z who have had experience teaching science during the COVID-19 pandemic. Using Google Form enabled data to be collected during the online class. A WhatsApp group was used to gather data, and all users were requested to reply to an online survey.

The respondents in the current work are Gen-Z who have had the experience of teaching science during the COVID-19 pandemic. A person who was born in the years between 1995 and 2012 is regarded a technology user and uses technology to study, socialize, go shopping, and do many more things than the previous generation (Aziz et al., 2021). The population in this work consisted of 748 respondents, while the sample of current work comprised 201 respondents from two provinces in Indonesia (see Table 1). The respondents were included in the following areas of specialization: Science (18.41%), Chemistry (44.28%), Physics (23.38%) and Biology (13.93%). The majority of the students (66.67% of the overall sample) were female, while 33.3% of the students were male. Of the total number, 25.37% and 74.62% were teachers and student teachers, respectively. Although the sample size was rather small in the present work, Chen et al. (2014) have indicated that a sample size of more than 100 is adequate for Rasch analysis.

Table 1. Sample of the study

Samples	**N (%)**
Area of specialization	201 (100%)
Science	37 (18.41%)
Chemistry	89 (44.28%)
Physics	4 (23.38%)
Biology	28 (13.93%)
Gender	201 (100%)
Male	67 (33.3%)
Female	134 (66.67%)
Source of experience	201 (100%)
Teacher	51 (25.37%)
Student teacher	150 (74.62%)

3.2 Instrument

The application of STEM by Gen-Z in their science teaching was evaluated using a locally developed instrument by Wahono and Chang (2019b) which has been applied in some studies, (i.e., Parmin et al., 2020; Wahono & Chang, 2019a). The instrument can be divided into seven sub-domains as the derivation of STEM disciplines. There were two disciplines (SAp-ST, SAp-SE, SAp-SM), three disciplines (SAp-STE, SAp-STM, SAp-SEM), and four disciplines (SAp-STEM), where SAp, T, E, and M refer to Science Application, Technology, Engineering, and Mathematics. The STEM application scale consisted of 26 items rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3.3 Data Collection Process

A consent letter was supplied before the online surveys were completed. In the first section, we obtained biographical information from participants, such as area of specialization, gender, and experience. In the second part, we examined the variables relevant to the research question. However, before the online surveys on STEM application instrument were conducted among Gen-Z generation, the current work employed back translation to validate the accuracy of the initial questionnaire's interpretation.

3.4 Data Analysis

After the data was collected, they were tabulated using Microsoft Excel to prepare for data analysis using Winsteps (Linacre, 2017, 2018) version 3.7.3 to analyse reliability, separation, item fit statistics, unidimensionality test, and rating scale calibration. The data analysis was performed separately for each sub-construct of the STEM application, based on the Rasch analysis. The core concept behind Georg Rasch's model is that an individual with more ability has a higher likelihood of answering any question of the kind in question, and that if one survey instrument being more challenging than the other indicates that an individual has a higher probability of answering the second test item (Rasch, 1960a). Rasch's analysis is probabilistic in nature and is based on logits (Rasch, 1960b), which enables the creation of a linear measure from ordinal observations (Linacre, 1999). The Rasch study started with an assessment of how well objects and respondents fit together (Abbitt & Boone, 2021). Rasch analysis is a powerful tool for examining the psychometric features of measurements and adjusting for response bias (Bradley et al., 2015). By employing the Rasch model, which falls under item response theory (IRT), we examined an instrument with fewer domains while keeping the psychometric features of the original measure. As a result, measurement accuracy and effectiveness increased. Data may be transformed using Rasch analysis in which the transformation from raw numbers to interval values is easy to read (Alnahdi, 2018). This investigation looked at the rating scale's quality, item quality in terms of identifying STEM application factors, how effectively the items reflect the STEM application range, and item function with regard to the subjects.

The STEM application's fit, item difficulty, response scale appropriateness, and person and item separation indices were all examined using Rasch analysis. According to Boone et al. (2014), there are several fit statistics to evaluate to ensure construct validity: (a) the value of accepted Correlation Points (Pt Mean Corr): 0.4 <Pt Measure Right <.085 (b) the value of accepted infit and outfit mean square (MNSQ): 0.5 <MNSQ <1.5. However, items having infit and outfit MNSQ values outside of this range (i.e., 0.6 <MNSQ <1.4) are regarded as misfitting (Aryadoust et al., 2020; Linacre, 2020). At the same time, scores greater than 2.0 indicate that the item is either being used inconsistently enough to skew the measurement model or that it is not a component of the structure under investigation (Linacre, 1999). Therefore, in the current work, when the Infit MNSQ score was less than 0.7 or larger than 1.3, and the Z score was less than 2.0 or higher than 2.0, items were deemed unsuitable. Furthermore, the separation and person indices as well as item reliabilities were also investigated in the present work. In Rasch modelling, the individual separation index and item separation index are employed to assess the test's reliability. Person and item reliabilities of greater than 0.7 are regarded as appropriate (see Boone & Noltemeyer, 2017), and the person separation index should be greater than 2.0 (Linacre, 1999). According to Andrich (1982), the reliability of separation is evaluated in the same way as Cronbach's alpha. Furthermore, the STEM application's construct unidimensionality was assessed utilising Rasch-based principal component analysis of model residuals (PCA-R). The measure was deemed unidimensional in this investigation if the Rasch factor explained more than half of the total variance in STEM application and the eigenvalue of the first contrast/first secondary factor was less than 2.0 (see Bravini et al., 2016; Chang et al., 2016). To assess the item difficulty of the STEM application, we employed a Wright map of Rasch analysis, which permits graphical analysis of participants and items on a map depicting the spread of responses.

4. Results

To answer the research question (Is the adopted STEM application instrument valid and reliable for Indonesian context using Rasch modelling?), we assessed the instrument validity and reliability, unidimensionality, item fit statistics, and Likert-rating scale.

4.1 Instrument Validity and Reliability

When validating a questionnaire based on the Rasch analysis, three types of reported reliability are utilised (Adams et al., 2021). It is a mathematical model based on the linear relationship between an object and a person, which is based on latent features (Scoulas et al., 2021). The reliability of STEM application instruments in the Indonesian context employing Winsteps software for item reliability (0.94), person reliability (0.96) and Cronbach's alpha (0.97) were adequate (see Table 2). Furthermore, the separation between the item and the person, should be greater than 1.5 to be regarded as appropriate (Suryadi et al., 2021; Tennant & Conaghan, 2007). The separation for item (4.67) and person (3.81) for the STEM application instrument in the Indonesian context was good. The excellent results of reliability and separation indicate great internal consistencies of the STEM application instrument (Iseppi et al., 2021).

Table 2. Validity and reliability of STEM application instrument

	Reliability			Separation		Chi-Square
	Cronbach	Item	Person	Item	Person	
SAp-ST	0.79	0.91	0.70	3.22	1.53	1262.71**
SAp-SE	0.71	0.96	0.67	5.10	1.42	950.2**
SAp-SM	0.80	0.93	0.75	3.51	1.75	799.57**

SAp-STE	0.86	0.89	0.84	2.84	2.27	734.78**
SAp-STM	0.76	0.96	0.71	4.80	1.55	992.49**
SAp-SEM	0.82	0.96	0.79	4.67	1.92	935.51**
SAp-STEM	0.88	0.89	0.86	2.80	2.50	1114.03**
All	0.94	0.96	0.91	4.84	3.26	9582.18**

4.2 Unidimensionality

The capacity of an instrument to estimate what the researchers aim to explore is measured by its unidimensionality. Here the researchers aimed to explore the STEM application of Gen-Z. The minimal raw variance explained was greater than 24% (Purnami et al., 2021). The Rasch model indicated unidimensionality via Principal Component Analysis (PCA) and local independence analysis. Nevertheless, the study only reported the PCA. The explained variance of the STEM application instrument for the Indonesian context surpassed the minimum score of 40%, meaning that the instrument was a valid instrument to measure STEM application constructs (see Table 3).

Table 3. Unidimensionality of STEM application instrument

	Explained Variance		
	By item	**By person**	**Total**
SAp-ST	36.3%	17.9%	54.1%
SAp-SE	39.6%	19.9%	59.5%
SAp-SM	49.5%	12.5%	62.0%
SAp-STE	63.4%	8.3%	71.8%
SAp-STM	43.7%	18.4%	62.0%
SAp-SEM	46.7%	15.9%	62.2%
SAp-STEM	57.1%	10.9%	68.0%
Entire instrument	23.7%	24.8%	48.5%

4.3 Item Fit Statistics

The examination of item fit statistics, such as mean square (MNSQ) and correlation points (Pt Mean Corr), provides evidence of construct validity (Table 4). Mean square (MNSQ) indicated the size of the discrepancies (i.e., randomness) while correlation points (Pt Mean Corr) tested the partial correlation of each item with the total measure score, separation statistics and item reliability (Alkhadim et al., 2021). For MNSQ, a value of 0.5-1.5 was accepted, and for Point Measure Right, a score of 0.4-0.85 was accepted. (Boone et al., 2014).

Table 4. Item fit statistics of STEM application instrument

	MNSQ		**ZSTD**		**Point Mea Corr**
SAp-ST1	0.87	0.88	-1.3	-1.2	0.81
SAp-ST2	0.96	0.96	-0.3	-0.4	0.80
SAp-ST3	1.16	1.22	1.5	1.9	0.71
SAp-ST4	1.00	1.00	0.00	0.1	0.77
SAp-SE1	1.22	1.32	2.0	2.6	0.70
SAp-SE2	0.90	0.90	-1.0	-1.0	0.84
SAp-SE3	0.83	0.83	-1.7	-1.7	0.84
SAp-SM1	1.00	0.99	0.00	-0.1	0.84

SAp-SM2	0.96	0.96	-0.3	-0.4	0.87
SAp-SM3	0.99	1.01	0.00	0.1	0.82
SAp-STE1	1.17	1.17	1.5	1.5	0.85
SAp-STE2	0.80	0.77	-2.0	-2.1	0.92
SAp-STE3	0.98	0.99	-0.1	0.00	0.89
SAp-STM1	1.04	1.05	0.4	0.5	0.82
SAp-STM2	0.82	0.84	-1.8	-1.6	0.81
SAp-STM3	1.10	1.04	0.9	0.4	0.77
SAp-SEM1	1.18	1.15	1.7	1.4	0.82
SAp-SEM2	0.76	0.75	-2.4	-2.5	0.89
SAp-SEM3	1.05	1.05	0.5	0.5	0.85
SAp-STEM1	0.92	0.91	-0.8	-0.9	0.88
SAp-STEM2	1.32	1.28	2.9	2.5	0.83
SAp-STEM3	0.78	0.80	-2.3	-2.0	0.87
SAp-STEM4	0.95	0.93	-0.5	-0.6	0.87

4.4 Likert-Rating Scale

The STEM application instrument had five Likert scales (strongly disagree, disagree, neutral, agree, and strongly agree; Wahono & Chang, 2019b) to express Gen-Z application when they took their roles as science teachers. This information was evaluated to allow the participants to comprehend and differentiate between the various categories (Adams et al., 2021). This analysis was useful in evaluating the precise number of Likert-scale items to use; it is possible to modify the scale into a smaller or larger range (Ishak et al., 2016). To calibrate the scale, the current research pivoted on the Rasch Andrich threshold with a desirable value of 1.40–5.0 logit (Van Zile-tamsen, 2019). The result of the analysis for each sub-domain is presented in Table 5.

Table 5. Rasch Andrich threshold of STEM application instrument

	SAp-ST	SAp-SE	SAp-SM	SAp-STE	SAp-STM	SAp-SEM	SAp-STEM	Entire instrument
Strongly disagree	None	None	None	None	None	None	None	None
Disagree	-3.86	-3.54	-4.09	-6.39	-2.38	-4.00	-5.98	-2.03
Neutral	-0.66	-1.41	-2.14	-2.25	-1.89	-1.49	-1.53	-1.01
Disagree	1.00	1.31	1.22	2.22	0.86	1.61	1.85	0.76
Strongly disagree	3.53	3.64	5.01	6.42	3.42	3.88	5.66	2.28

5. Discussion

The goal of this study was to investigate the adopted STEM application instrument (Wahono & Chang, 2019b) in higher educational levels in the Indonesian context using Rasch modelling analysis. Overall, the current study's results indicated that the adopted STEM application instrument is adaptable to different cultural settings. In response to the research question, the current work proved that the adopted STEM application instrument had an acceptable Rasch model characteristic in general. In accordance with the work of Wahono and Chang (2019b), all seven sub-domains were unidimensional. The current findings were completely compatible with those of prior works (Parmin et al., 2020;

Wahono & Chang, 2019a; Wahono & Chang, 2019b), and the current work found that the parallels between the current study and earlier studies on the adopted STEM application instrument stem from the greater education level of populations that demand sophisticated viewpoints. Some scholars argue that the Rasch model is used to determine deviant answers, such as person-fit statistics and item-fit statistics (Widhiarso & Sumintono, 2016), person answers and quality of tool (Bond & Fox, 2015), and concentrates only on item fit statistics (Widhiarso & Sumintono, 2016). Moreover, since the current instrument employed the Likert-scale, it was important to transform the data to a ratio or interval scale to get a more reliable instrument. Alnahdi (2018) indicates that the transformation from raw numbers to interval values is easy to comprehend because each modification in one component has comparable weight across the scale.

In the current work, the STEM application's fit, item difficulty, response scale appropriateness, and person and item separation indices were all examined using Rasch analysis. The adopted STEM application instrument for the Indonesian context could be used as a valid and reliable measure. Generally, Principal Component Analysis (PCA) and local independence analysis in the Rasch analysis imply unidimensionality. However, the current work reported only the PCA. The discrepancy between an actual and predicted score is known as the PCA residual value (Ishak et al., 2018). The explained variance of the STEM application instrument for the Indonesian context surpassed the minimum score of 40%, meaning that the instrument can be used as a valid instrument for measuring the adopted STEM application constructs. The separation for item and person for the STEM application instrument in the Indonesian context were 4.67 and 3.81, respectively. The great internal consistency of the instrument was demonstrated by the outstanding outputs of reliability and separation, implying that the instrument can effectively divide items and persons into some categories (Iseppi et al., 2021). Again, in this study, some items revealed high ZSTD scores, indicating a significant misfit, which was one type of measure other than MNSQ, point measure correlation, and separation. It may be worthwhile investigating whether deleting these elements improves the measuring qualities of the ZSTD scores in future investigations. However, the fulfilment of other measures suggested the neglect of the high ZSTD score (Alkhadim et al., 2021). In the adopted STEM application constructs, the Rasch modelling results likewise revealed a considerable dispersion of measures over the logit scale in item difficulty level. The study has contributed to a new body of knowledge in terms of validating teachers' applications of STEM for Gen-Z in Indonesian classrooms during the COVID-19 pandemic.

6. Conclusion

A vital contribution of the current research is the validation of STEM applications for the Indonesian Gen-Z generation using Rasch analysis. The findings of the current study revealed that each sub-construct fulfilled a minimum of 0.65 for Cronbach's alpha, item, and person reliability, and most of them had more than 1.5 for person and item separation. At the same time, each item had a good score of the mean square, Z-tolerated standard, and point measure correlation, indicating the fulfilment of the Rasch measurement model. The analysis also demonstrated the unidimensionality assumption and an excellent rating scale. This implies that the instrument could be a reference for universities and school principals to assess Gen-Z teachers' STEM integration during their teaching.

Although the tools of STEM application are extensively used in Indonesia, and the measure has the potential to be utilised for research and practice in this environment, the current work acknowledges that this study had significant flaws. Firstly, a limitation was the number of survey instruments (AKA) towards attitude, knowledge, and application on the STEM scale. However, the current study only involved the domain of application of STEM, including seven sub-domains, because the current work focused only on the application of STEM among the Indonesian Gen-Z generation. Secondly, because of the COVID-19 pandemic scenario, convenience sampling (a non-probability sample) was used in this study, which was based on participant proximity and accessibility. This approach may not provide a complete picture of the individuals in the study areas. Future research should try to collect data from a variety of sources. Thirdly, female learners outnumbered male students. Because the current study explored the possibility of variability in respondents' replies based on location, this instrument can be used to investigate gender prejudice in rural and urban areas. Future research should explore the evidence from a variety of backgrounds.

7. References

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