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ACADEMIC SELF-EFFICACY INVENTORY: USING RASCH ANALYSIS TO DEVELOP AND EVALUATE SELF-EFFICACY RATING SCALES

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ABSTRACT

As many studies have proven, self-efficacy positively affects learning performance. Therefore, many instruments have been developed to measure self-efficacy. To be used for educational purposes, the instrument must be proven valid and reliable. This study aims to develop and evaluate the Academic Self-Efficacy Inventory (ASEI) that meets the criteria to be applied as a self-efficacy instrument. This research is a two-phase study designed following the recommendations for scale design and development. A total of 505 Indonesian high school students majoring in science were involved as respondents to test the 20-item rating scale. As a result, all questionnaire items met the fit category with an item reliability score of 0.94, and the unidimensionality scale also met the variance value explained by measures and unexplained variance criteria. Thus, ASEI is declared suitable, reliable, and valid for measuring students' self-efficacy on the topic of light and sound waves. This research provides results in the form of a self-efficacy instrument on the topic of light and sound waves and a validity test with a high value, which is useful for readers to have confidence in the quality of the study results.

Keywords: light and sound waves; rasch analysis; self-efficacy

INTRODUCTION

According to the 2022 U.S. Bureau of Labor Statistics, 12 of the 20 fastest-growing jobs involve science (Bureau of Labor Statistics, 2022; Dubina et al., 2022; Wade et al., 2022). Unfortunately, learning loss due to the COVID-19 pandemic has made many students lose self-efficacy in learning science (Donnelly & Patrinos, 2021; Saline, 2021; Zorkić et al., 2021). Self-efficacy greatly influences learning performance (Yadav et al., 2021). Self-efficacy, or beliefs about one's ability to do specific activities or tasks, has been found to be a strong predictor of effort (Galla et al., 2014; Teng, 2021). Many studies have shown that high self-efficacy is positively related to student academic achievement (Nasir & Iqbal, 2019; Cai et al., 2021; Stolz et al., 2022). However, there are still many misunderstandings regarding self-efficacy; most people think that self-efficacy is a constant and unchanging ability (Peura et al., 2021) when, in fact, self-efficacy can develop and change, so the teacher should measure students' self-efficacy in each learning topic. This can help discover students' skills and interests (Huang et al., 2019; Guo et al., 2020; Hendrickson, 2021).

A theory states that efficacy ideals are shaped by how someone perceives and interprets facts from 4 foremost sources: mastery experiences, verbal and social persuasions, vicarious experiences, and physiological and emotional states (Bandura et al., 1997). However, because self-efficacy can change constantly, several studies have taken a fixed approach to the many variables related to self-efficacy, for example, research conducted by Gao (2021), who believe that learning models

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have an influence on self-efficacy and Supratman et al. (2021) who believe that different learning approaches have different effects on self-efficacy.

The concept of self-efficacy has been widely known in education. Self-efficacy was originally introduced through Albert Bandura's social cognitive theory. Bandura proposes that self-efficacy can be defined as an individual's belief in their ability to successfully achieve a goal or perform an action (Magni & Manzoni, 2020; Koutroubas & Galanakis, 2022). Self-efficacy can influence their actions to choose, determine efforts, achieve something they want, and build resilience to deal with obstacles or failures in life (Creely et al., 2021; Renko et al., 2021). Someone confident in their abilities can be optimistic about new challenges and set goals for themselves (Tangkeallo et al., 2014; Tus, 2020). High individual perceptions of their abilities will result in better performance (Emmons & Zager, 2018; Nasir & Iqbal, 2019; Aguilera-Hermida, 2020). This applies to any condition, including cognitive terms in education. Therefore, the higher the self-efficacy, the more likely people will feel confident completing a particular task. These beliefs will influence actions and behavior and obviously impact achievements.

For high school students, confidence in making decisions is very important for growth (Scherrer & Preckel, 2019; Yeager et al., 2019). High school students must decide whether they will enroll in college or find jobs, what field of work they want to pursue, and what skills they want to learn. As a result, experts believe that self-efficacy in decision-making plays a crucial role in high school students' career growth (Falco & Summers, 2019; El-Hassan & Ghalayini, 2020; Frith et al., 2020; Koçak et al., 2021). Self-efficacy in career decisions refers to an individual's confidence in their capacity to make commitments and choices about the occupations they want to pursue (Taylor & Betz, 1983; Falco & Summers, 2019; Xin et al., 2020; Chui et al., 2022).

Self-efficacy can change and develop (Yuen et al., 2004; Burnette et al., 2020; Brann et al., 2021; Supratman et al., 2021), therefore monitoring student self-efficacy in learning becomes very important (Kok et al., 2020; Cai et al., 2021). Many studies have revealed the results of evaluating student self-efficacy and have also been conducted to develop self-efficacy instruments. A study examining teachers in rural Midwestern areas has succeeded in developing a mental health self-efficacy instrument (Brann et al., 2021). Another study conducted in Italy developed a psychometrically tested self-efficacy scale for ostomy care nursing management (Dellafiore et al., 2020). For high-school level, many researchers have also evaluated self-efficacy with instruments developed on various learning topics (Pajares & Miller, 1995; Yuen et al., 2004) in mathematics (Bergqvist et al., 2020; Öztürk et al., 2020; Supandi et al., 2021), English (Torres & Alieto, 2019; Zhang & Ardasheva, 2019; Zhang et al., 2020), and science (Usher et al., 2019; Fidan & Tuncel, 2021; Mohd Dzin & Lay, 2021). The large amount of research related to the evaluation and development of self-efficacy instruments proves that the development of instruments and evaluation of self-efficacy is important; by knowing students' self-efficacy, teachers can determine the best steps they can take for learning (Ayllón et al., 2019; Dorfman & Fortus, 2019; Ma et al., 2021; Wei et al., 2021).

Rasch model, also known as the one-parameter logistic model, is a psychometric model within the framework of item response theory (IRT) (Bond & Fox, 2015; Qian & Wang, 2020; Lipovetsky, 2021). Rasch model was conceptualized and developed by the mathematician Georg Rasch after identifying certain issues by utilizing unprocessed examination results (raw test scores) (Bond & Fox, 2015; Elliot et al., 2016). Rasch model creates a scale for interpreting an action or thing as measured by useful psychometric properties (Boone & Noltemeyer, 2017; You et al., 2018; Fernanda & Hidayah, 2020). As a result, the Rasch model offers several ways to assess the reliability and validity of data collected through instruments such as tests and surveys (You et al., 2018).

As mentioned earlier, numerous tools have been created to assess self-efficacy, but challenges persist in locating instruments tailored for gauging high school students' self-efficacy in highly specific subjects like light and sound waves. By conducting self-efficacy assessments for each topic, teachers can identify the areas where each student feels most confident, enabling them to take more targeted actions. This study addresses this gap by developing a self-efficacy instrument for high school students focusing on a specific topic. This study's choice of light and sound waves is arbitrary, with no particular rationale.

Recognizing the significance of analyzing students' self-efficacy and its evolution, this research aims to create and evaluate the Academic Self-Efficacy Inventory (ASEI) to meet the criteria for application as a self-efficacy tool. Considering that self-efficacy can be influenced by treatment and the learning process, many researchers emphasize the importance of develo-

ping self-efficacy instruments based on students' needs. Despite the existence of reliable and valid self-efficacy instruments in various fields, finding instruments to assess high school students' self-efficacy in highly specific areas, such as light and sound waves, remains challenging. Therefore, this research contributes to advancing the development of an Academic Self-Efficacy Inventory with a specific focus on light and sound waves.

METHODS

The requirement for respondents in this study is that students must have studied the topic of light and sound waves at school. Therefore, students must come from a science or special physics class. Respondents included eleventh and grade-12 students majoring in science (n = 505) from several high schools in a province in Indonesia.

This research was a two-phase study designed following the recommendations for scale design and development (Rattray & Jones, 2007; Dellafiore et al., 2020). Phase 1 comprised the conceptualization stage, delineated by three key steps. Initially, a thorough literature review was conducted to delve into self-efficacy instruments and discern requirements. Subsequently, a team convened to deliberate on findings from diverse studies concerning self-efficacy, with a focus group discussion to pinpoint the self-efficacy scale to be employed. Lastly, the phase involved crafting instrument items, drawing from the Missouri guidance curriculum tailored to self-efficacy dimensions: 1) time management, 2) study and examination skills, 3) learning from peers, 4) educational planning, and 5) fostering responsibility in learning. This entailed identifying an initial set of items through a panel discussion among the research project team members.

The second phase involved validating the items through three steps. First, a panel of five experts evaluated the content validity of the item set. The criteria evaluated in expert judgment included the quality of the instrument's content, internal consistency, interpretability, and appropriateness of assessment criteria (such as the availability of rubrics). Second, forms were distributed to high school students in grades 11 and 12 who majored in Natural Sciences in Lampung province, with a total of 505 students participating. Third, data analysis was conducted using the Rasch Model with the Winstep Rasch analysis program application (Yasin et al., 2015; Guzey & Jung, 2021). The Rasch Model was chosen to align with the research's goals, enabling precise assessment of individual items and their contribution to the overall construct. Item fit statistics, like infit and outfit indices, were used to ensure items fit the model well. Construct validity was established by comparing theoretical expectations with empirical data. This approach ensured robust analysis and interpretation per the research's objectives.

In the third stage of the first phase, before compiling the measurement items, point items were first made. These points were developments from Yuen's Academic Development Self-Efficacy category (Yuen et al., 2004), which in this study was referred to as the Academic Self-Efficacy Inventory (ASEI). Aspects of self-efficacy in ASEI were measured on several skills, such as time management, mastering study and examination, educational planning, learning from friends, and being a responsible learner. The level of self-efficacy in Yuen's model of AD-SEI is displayed on a Likert scale with 6 levels of self-efficacy, where point 1 represents extremely not confident, and point 6 represents extremely confident. The development of each item can be seen in Figure 1.

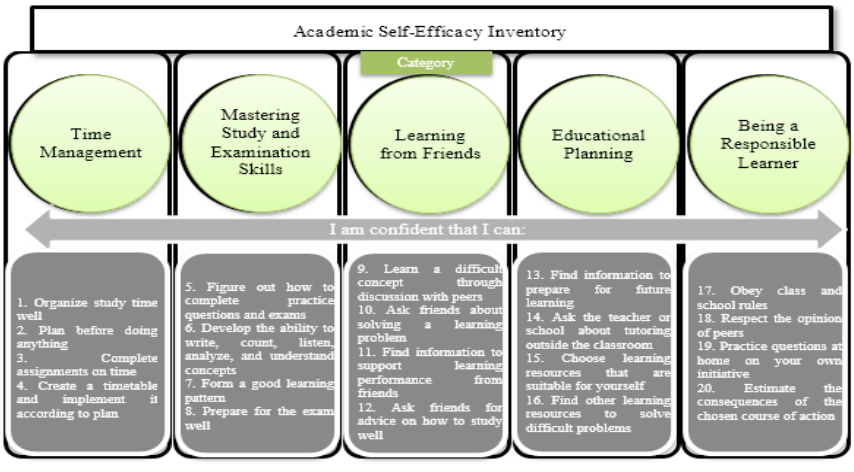

Figure 1. Academic Self-Efficacy Inventory Item Points

Figure 1 shows the item points to be measured. These points were developed by adopting Yuen's Academic Development Self-Efficacy item points. Because there are 5 categories in this scale, it helps the teachers see the situation and get to know students better. The teachers can more clearly identify which category students feel confident that they are capable of and which category students feel less confident about their abilities.

After the research team approved these points, they were developed into an Academic Self-Efficacy Inventory questionnaire with 20 measurement items, which were then prepared to be tested for validity.

To see the level of suitability of the items, the item fit order test was conducted. This test was carried out to see the accuracy of the item in measuring what should be measured (Bond & Fox, 2015). Item fit was determined by the MNSQ, ZSTD, and PT Measure Corr values with criteria: MNSQ value $0.5 < x < 1.5$, ZSTD value $-2 < x < +2$, and PT Measure Corr. value $0.4 < x < 0.85$ (Linacre, 2010; Bond & Fox, 2015). If one or two criteria are met, the item can still be maintained and does not need to be changed; in other words, the item is declared fit (Nurdini et al., 2020; Dewi et al., 2021). The item is declared a misfit if the three criteria are not met, then it is certain that the item is not good enough, so it needs to be repaired or replaced (Nurdini et al., 2020; Dewi et al., 2021). To determine the construct validity of the instrument, unidimensionality was evaluated. This was achieved through a Principal Components Analysis of Raw Residual Variance in Eigenvalue Units. If the Rasch measurement yields a reasonably high percentage of raw explained variance (at least 40%), and the initial residual components of unexplained variances have less than two eigenvalues, the data might be assumed to be fundamentally unidimensional (Linacre, 2010; Bond et al., 2020). The reliability test using the Rasch model is based on the interaction between the person and the item questions (item-person) and the level of consistency of students' answers (person reliability) (Bond & Fox, 2015). Item-person interaction can be analyzed using the Cronbach Alpha value.

RESULTS AND DISCUSSION

This study is conducted in two phases. As explained in the method, the first phase consists of three stages that result in the instrument's initial design. In the second phase, a new validation process begins. The second phase consists of content validation and revision, data collection, and data analysis.

A panel of five experts judges instrument content validation. Of the 20 self-efficacy instrument items, no significant improvements were proposed by experts. Based on the cumulative results of expert judgment, the instrument has been declared very feasible with a score of 89.2%.

After expert judgment has been carried out, it enters the data collection stage. Data has been collected in two ways: first, by distributing online forms to eleventh and twelfth-grade students in several high schools in Lampung province, Indonesia, and second, by distributing questionnaires to students directly because some schools in rural areas do not have internet access. After three months of data collection, data obtained from 505 respondents are ready to be analyzed.

The fit order item test aims to see the quality of each item in testing self-efficacy. The results of the fit order items for each item are presented in Table 1.

Table 1. Item Fit Order

No	Items	Infit		Outfit		PT-Measure CORR	Conclusion
	I am confident that I can…	MNSQ	ZSTD	MNSQ	ZSTD		
1.	manage my time well so that I can study light and sound waves well	0.78	-3.81	0.80	-3.46	0.91	Fit
2.	answer questions related to the speed of sound wave propagation, resonance, sound intensity, light waves, interference, dispersion, and light polarization	0.84	-2.67	0.89	-1.88	0.88	Fit
3.	understand difficult concepts through discussions with peers	1.25	3.68	1.18	2.78	0.87	Fit
4.	find information to prepare for the next Physics learning topic	0.92	-1.27	0.89	-1.86	0.90	Fit
5.	comply with school rules and class rules properly	1.23	3.41	1.18	2.67	0.88	Fit

No	Items	Infit		Outfit		PT-Measure CORR	Conclusion
	I am confident that I can…	MNSQ	ZSTD	MNSQ	ZSTD		
6.	plan how to do the assignments given by the teacher	1.17	2.62	1.18	2.78	0.87	Fit
7.	improve my writing, counting, listening, analysis, and understanding of the concept of light and sound waves if I continue to study consistently	1.09	1.35	1.11	1.76	0.88	Fit
8.	ask friends how to solve problems related to the concept of light and sound waves if I cannot find the solution through the learning resources I have	0.92	-1.24	0.90	-0.21	0.87	Fit
9.	ask the teacher about concepts I do not understand through outside-of-class learning	0.97	-0.51	0.97	-0.40	0.88	Fit
10.	respect the opinions of my classmates even if they contradict what I believe	1.29	4.20	1.40	5.53	0.86	Fit
11.	complete the light and sound wave task on time	0.69	-5.51	0.74	-4.51	0.90	Fit
12.	build good study habits in order to master the concept of light and sound waves well	0.96	-0.64	0.94	-0.88	0.88	Fit
13.	seek information from friends regarding learning resources that can support me in learning light and sound wave topic	0.85	-2.52	0.87	-2.13	0.88	Fit
14.	choose light and sound wave learning sources that are suitable for me	0.74	-4.54	0.77	-3.93	0.90	Fit
15.	practice the ability to solve light and sound wave questions at home	0.99	-0.12	0.99	-0.06	0.88	Fit
16.	design a timetable for learning the light and sound wave topic and implement it	1.06	0.89	1.07	1.05	0.86	Fit
17.	prepare for the light and sound wave exam well	0.93	-1.14	0.90	-1.62	0.90	Fit
18.	ask for advice from peers regarding how to understand the light and sound wave topic	0.95	-0.79	0.96	-0.63	0.87	Fit
19.	find other learning resources to solve difficult problems of light and sound waves	0.95	-0.74	0.94	-1.00	0.89	Fit
20.	understand that if I do not prepare well, I will not be able to master the light and sound wave concept	0.97	-0.39	0.95	-0.78	0.89	Fit

As displayed in Table 1, 20 of the 20 self-efficacy measurement items for high school students in studying the topic of sound and light waves have been declared fit because they have met the requirements 0.5 < infit and outfit MNSQ value < 1.5 (Bond & Fox, 2015) or 1 of 3 item requirements have met the criteria. Because the 20 items were declared fit and met the quality for measuring self-efficacy, a unidimensionality test was carried out. The complete unidimensionality measurement results are presented in Table 2.

Table 2. Raw Residual Variance in Eigenvalue Units

	Eigenvalue	Observed (%)	Expected (%)
Total raw variance in observations	142.5121	100	100
Raw variance explained by measures	117.5121	82.5	82.0
Raw variance explained by persons	67.0628	47.1	46,8
Raw variance explained by items	50.4494	35.4	35,2

	Eigenvalue	Observed (%)		Expected (%)
Raw unexplained variance (total)	25.000	17.5	100.0	18.0
Unexplained variance in first contrast	3.6211	2.5	14.5	
Unexplained variance in the second contrast	3.134	2,3	13.3	
Unexplained variance in the third contrast	2.3572	1.7	9.4	
Unexplained variance in the fourth contrast	2.1047	1.5	8.4	
Unexplained variance in the fifth contrast	1.6827	1.2	6.7	

Based on the results of the raw residual variance in eigenvalue units in Table 2, the raw explained variance value reaches 82.5%, which is more than 50%, so it can be said that it has met the dimensionality criteria (Bond & Fox, 2015; Chan et al., 2021). This means this instrument is not heavily contaminated by other factors interfering with measurement. In other words, this self-efficacy instrument's scale can precisely measure self-efficacy indicators. The reliability of any set of measurements is logically defined as the proportion of their true variance. Meanwhile, separation is the number of statistically different performance strata the test can identify in the sample (Wright, 1996; Bond & Fox, 2015). The reliability test using the Rasch model is based on the interaction between the person and the item questions (item-person) and the level of consistency of students' answers (person reliability) (Bond & Fox, 2015). The results of the reliability and separation tests are presented in Table 3.

Table 3. Reliability and Separation

Person	**505 Input**		**505 Measured**		**Infit**		**Outfit**	
	Total	**Count**	**Measure**	**Realse**	**IMNSQ**	**ZSTD**	**OMNSQ**	**ZSTD**
Mean	74.9	20.0	.40		.98	-.3	.99	-.2
P.SD	27.6	.0	2.54		.59	1.7	.61	1.7
Real RMSE	.40	TRUE SD	2.51	SEPARATION 6.32			PERSON RELIABILITY .98	
Item	**20 Input**		**20 Measured**		**Infit**		**Outfit**	
	Total	**Count**	**Measure**	**Realse**	**IMNSQ**	**ZSTD**	**OMNSQ**	**ZSTD**
Mean	1890.9	505.0	.00	.06	.98	-.5	.99	-.3
P.SD	64.9	.0	.25	.00	.16	2.6	.16	2.4
Real RMSE	.06	TRUE SD	.25	SEPARATION 3.82			ITEM RELIABILITY .94	

The results of the person reliability test are recorded at 0.98 in the category of excellent and separation index (6.32) > 2, and the reliability of the items is recorded at 0.94 in the category of Good, Separation index (3.82) > 2. This means that all items can work well in the same direction in measuring students' self-efficacy in learning the topic of light and sound waves (Linacre, 2018).

The current research presents the results of item fit order, unidimensionality (validity), and reliability from the results of developing a self-efficacy instrument on the topic of light and sound waves for high school students. All test results, both from the panel of experts and the Rasch analysis, state that this instrument is feasible and practical. By developing self-efficacy instruments specific to certain learning topics, teachers will become more aware of their students' efficacy level, which will help them determine the next step of learning.

The Academic Self-Efficacy Inventory consists of 20 statement items that adopt the high school student self-efficacy measurement scale developed by Yuen et al. (2004). Of the 20 items measuring student self-efficacy in learning sound and light waves, they were tested on 505 high school students in Lampung. The twenty items have been declared fit because they have an MNSQ value of 0.5 <infit & outfit value <1.5, according to the literature (Bond & Fox, 2015). Person reliability is recorded at 0.98 in the excellent category and separation index (6.32)> 2, and item reliability was recorded at 0.94 in the good category and separation index (3.82)> 2. Meanwhile, in the value of the correlation me-

asurement, the twenty items had a positive value of 0.83-0.91. This means that all items can work well in the same direction in measuring students' self-efficacy in learning the material of sound waves and light waves. Thus, the unidimensionality scale is fulfilled, with the value of the variance explained by measures of (82.5%) > 50% and the unexplained variance in first contrast of (2.5%) < 10%. This means this instrument is not heavily contaminated by other factors interfering with measurement. In other words, this self-efficacy instrument's scale can precisely measure self-efficacy indicators.

Many previous studies have also developed self-efficacy measurement scales, such as the development of a science teacher efficacy belief instrument (STEBI-B) for teachers (Slater et al., 2021), the development of self-efficacy instrument for vocational music education students (Özer Akçay, 2021), self-efficacy instruments for university students' perceptions in online learning environments (Yavuzalp & Bahcivan, 2020), and many more. Although many previous studies about the development of self-efficacy instruments have been found, this research provides a new flavour by focusing on high school students and measuring self-efficacy with more specific topics.

The light and sound wave topic in this study has been chosen randomly because the measurement items in this instrument are structured to be adapted to all learning topics. Therefore, the results of this research can greatly facilitate teachers in measuring student self-efficacy more specifically in each lesson because self-efficacy instruments made to measure learning topics specifically are still difficult to find. Self-efficacy is an ability that is not constant and can develop (in a negative or positive direction), so knowing the development of students' self-efficacy in each lesson will help teachers determine what steps to take next.

Previously, many studies have been conducted to develop self-efficacy instruments for the high school level. Many researchers have also evaluated self-efficacy with instruments developed on various learning topics (Pajares & Miller, 1995; Yuen et al., 2004), such as in mathematics (Bergqvist et al., 2020; Öztürk et al., 2020; Supandi et al., 2021), English (Torres & Alieto, 2019; Zhang et al., 2020; Zhang & Ardasheva, 2019), and science (Usher et al., 2019; Fidan & Tuncel, 2021; Mohd Dzin & Lay, 2021). The large amount of research related to the evaluation and development of self-efficacy instruments proves that the development of instruments and evaluation of self-efficacy is important. However, developing self-efficacy instruments that measure specific topics is still difficult. This research has brought a new finding by developing an Academic Self-Efficacy Inventory with a specific topic of light and sound waves. The finding of this research provides assistance for teachers to be able to prepare lessons better because prepared teachers are good teachers. As stated in previous studies, by knowing students' self-efficacy, teachers can determine the best steps they can take for learning (Chrisnayanti, 2021; Ma et al., 2021; Wei et al., 2021; Abduh et al., 2022).

A notable innovation in this research is the successful development of an Academic Self-Efficacy Inventory focusing on light and sound waves. While previous studies have extensively explored and assessed self-efficacy instruments for high school students across various learning topics, the novelty lies in addressing the challenge of result instruments that measure self-efficacy in specific subjects. The research offers a solution to this gap, presenting a novel Academic Self-Efficacy Inventory tailored to light and sound waves. This result advances the field and provides practical assistance to teachers, enabling them to prepare lessons better and enhance their effectiveness in the classroom.

Given the significance of developing the Academic Self-Efficacy Inventory focusing on light and sound waves, future research could expand upon this work by developing similar domain-specific self-efficacy instruments for other science topics or subjects. This could involve creating instruments tailored to specific branches of science such as biology, chemistry, or physics or even extending to other academic domains like mathematics, literature, or history.

Additionally, further research could explore the effectiveness of these domain-specific self-efficacy instruments in predicting academic performance and informing instructional practices. Investigating how students' self-efficacy in specific subjects correlates with their learning outcomes and engagement could provide valuable insights for educators in designing targeted interventions and support systems.

Furthermore, considering the importance of teacher preparation and efficacy in facilitating student learning, future studies could delve deeper into the relationship between teacher preparedness, student self-efficacy, and academic achievement. Exploring strategies for enhancing teacher efficacy and its impact on students' outcomes within subject-specific self-efficacy could offer valuable implications for educational policy and practice.

CONCLUSION

This research has successfully developed an Academic Self-Efficacy Inventory for high school students focusing on one learning topic. Based on panel experts, the items in this instrument have met the quality of self-efficacy measurement. Based on the Rasch analysis, all questionnaire items met the fit category with an item reliability score of 0.94, and the unidimensionality scale met, with variance value explained by measures and unexplained variance in first contrast met the criteria. Thus, ASEI is declared suitable, reliable, and valid for measuring students' self-efficacy on the topic of light and sound waves.

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