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Developing an Instrument for Scientific Attitude Assessment In Learning Chemistry

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Abstract: A component of the learning process, attitude reflects the development and comprehension of the attitudes of individual students. The cultivation of scientific attitudes among students remains a relatively unacknowledged educational objective. The objectives of this study are as follows: (1) developing the framework of a scientific attitude assessment instrument intended for high school chemistry lesson; and (2) establishing the reliability and validity of the developed scientific attitude assessment instrument. This study performs instrument development research in the affective domain in accordance with Gable & Wolf's (1993) research procedures. The participants in this study comprised a sample of 250 high school students. The Result of this research is the Honesty factor is the most influential in this instrument; cooperation, on the other hand, has the weakest loading factor value at 0.881. The SEM model as a whole has good capabilities in terms of matching sample data (Good Fit).

Keywords: Instruments; Scientific Attitude; SEM

Introduction

Education is widely regarded as a vital component of life that is believed to enhance the quality of life by enhancing knowledge, skills, and experience. Learning activities play a crucial role in determining learning outcomes within the realm of education (Kurniawan, Astalini & Sari 2019). Education is primarily a process aimed at cultivating the inherent capabilities of individuals, particularly students, through the provision of guidance and facilitation in their learning activities.

The attitudes of students are crucial in the learning process, since they are demonstrated through both positive and negative behaviors that might impact the results of learning. Positive attitudes, such as being diligent in studying, are correlated with getting satisfying outcomes, whereas negative attitudes, such as a lack of diligence, can adversely affect the attainment of poor results (Kurniawan, et al., 2019). The significance of attitudes in the process of learning also include the cultivation of students' scientific attitudes, which regrettably continue to be insufficiently acknowledged.

This attitude reflects the individual student understanding and advancement, emphasizing the principles and recognition of science. Hence, it is imperative to prioritize initiatives aimed at cultivating students' scientific attitudes as a fundamental objective within the educational journey, with the aim of enhancing the overall quality of education and fostering the comprehensive development of students. Scientific attitudes and attitudes towards science are distinct because attitudes towards science solely pertain to students' enjoyment of learning science, as opposed to broader scientific attitudes (Anwar, 2009). Attitude towards science refers to a predisposition that might manifest as either embracing or rejecting science itself (Darmawangsa, Astalini, & Kurniawan, 2018).

Students' scientific attitudes refer to the development of attitudes that are fostered via the implementation of the learning process, which includes engaging in experimental activities, participating in discussions, working in groups, and overall learning. Evaluating scientific attitudes is a crucial element in the advancement of science worldwide in the present era (Khan, et. al, 2012). According to Vello (2015),

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maintaining a happy attitude while learning can enhance student learning outcomes, and the reverse is also true. Assessing scientific attitudes holds the same level of importance as assessing cognitive knowledge and psychomotor scientific process skills.

By cultivating a scientific attitude, it is expected that students will possess a sense of curiosity to seek answers for each subject they study, display honesty in reporting opinions, discussions, and activities such as observation reports and discussion reports, demonstrate meticulousness in accurately observing various subjects of study, exert diligent efforts to obtain solutions or answers to the problems being investigated, exhibit perseverance by continuously exploring alternative test answers or conducting observations, and remain receptive to novel ideas from others (Tursinawati, 2017).

Teachers can update the learning design in the classroom to meet the skills of students if the teacher is able to assess students' scientific attitudes throughout learning (Astalini et al., 2019; Kurniawan & Astalini, 2019). Students with a strong scientific attitude will have an enhanced learning experience, as a scientific attitude fosters creative and critical thinking in students (Trumper, 2006). The attitude displayed during the learning process is crucial to having a favorable impact on students' academic performance. Acquiring scientific attitudes necessitates the utilization of instruments and assessments throughout the learning process (Fatonah, 2014).

Research on students' scientific attitudes is infrequently undertaken in educational settings, possibly due to the predominant focus on enhancing their academic performance or cognitive abilities. The importance of a scientific approach is often undervalued in an educational system that prioritizes standardized exam outcomes. Furthermore, the absence of reliable and standardized instruments to assess students' scientific attitudes can impede the progress of this research.

This research requires extra effort in designing effective research instruments and collecting data from a large enough sample of students to draw meaningful conclusions. Nonetheless, research on students' scientific attitudes has the potential to provide valuable insights into the factors that influence students' interest and engagement in science. By better understanding students' attitudes toward science, educators can develop more effective learning strategies and stimulate their interest in exploring the world of science. Encouraging further research in this area could contribute to the development of science education that is more holistic and oriented towards student development.

Assessment is the application of various methods and the use of various assessment tools to obtain information about the extent of student learning outcomes or the achievement of students' competencies (set of abilities) (Rosidin, 2017). Researchers always use assessment instruments to plan and accommodate their activities for the systematic data collection process in order to provide evaluations (Widoyoko, 2013).

Educators place more emphasis on assessing knowledge than attitudes. The availability of attitude instruments, development capabilities, and time are the main reasons for the difficulties faced in conducting attitude assessments. This condition gives special attention to developing and improving the quality of assessment tools for evaluating attitudes. Attitude assessment using developed instruments can make the process more meaningful, objective, and comprehensive (Kusumawati, 2015). This research aims to: (1) design the construct of a scientific attitude assessment instrument for chemistry learning in high school; and (2) prove the validity and reliability of the scientific attitude assessment instrument for high school chemistry learning that was developed.

Method

This study employed a quantitative approach, utilizing approaches to research focused on development. The study model employed an instrument development model in the affective domain proposed by Gable & Wolf. The selection of Gable & Wolf's instrument creation methodology in the affective domain was based on its esteemed reputation, robust theoretical foundation, and shown efficacy in assessing affective features.

In this research on the development of a scientific attitude instrument, several analysis processes were carried out to prove content validity, construct validity, and SEM (Structural Equation Model).

1. *Content Validity*

To prove that the content contained in the instrument items was valid, it was done using the Delphi technique by asking for expert judgment regarding the instrument being developed by some procedures for calculating and determining the statistical significance of the content validity coefficient (V) with the Aiken (1985) formula. A valid item had a calculated V value at least the same as the table V value (Aiken, 1985). Content validity related to the instrument's ability to accurately describe the aspects to be measured. The content validity steps were described in detail in the form of a grid, and the indicators are described. Next, the validation process for the scientific attitude instrument involved five experts in the field of chemistry.

2. *Construct Validity using Factor Analysis*

To obtain evidence of construct validity, an overall model fit evaluation was carried out and a measurement model fit evaluation was carried out using 2nd order confirmatory factor analysis (2nd CFA) assisted by the Lisrel version 8.0 program. The data deemed to match the model were met in 3 minimum requirements, namely RMSEA value ≤ 0.08, p-value > 0.05, and Probability Chi-squares > 0.05. Apart from these three requirements, there were several other Goodness of Fit (GOF) parameters which met certain criteria. Summary of the cutoff limits for the fit model of the GOF measured based on the concepts of Hooper, Coughlan, & Mullen (2008), Hair et al. (2010), and Dachlan (2014) is presented in Table 1. All GOF parameters are expected to meet the target level of suitability or have a good fit category.

Table 1. Summary of GOF Measures and Match Level Targets

GOF size	Target Match Level
Chi-square	$X^2 \leq 2\ df$
p-value	$p > 0.05$
RMSEA	≤ 0.08
GFI	≥ 0.90
CFI	≥ 0.90
NFI	≥ 0.90
SRMR	≤ 0.08

After the data is a good fit or declared to match the model, the next step is to check the construct validity of each indicator item. The instrument construct requirements meet valid criteria if the t-value is greater than 1.96 and the standardized factor loading (SLF) value is at least 0.3 (Igbaria et al., 1997; Hair et al., 2010). Instrument items that do not meet the requirements need to be reviewed or not used again at a later stage.

Factor analysis is a technique used to look for factors that are able to explain the relationship or correlation between various independent indicators that are observed. Factor analysis is an extension of principal component analysis. It is also used to identify a relatively small number of factors that can be used to explain a large number of interconnected variables.

Analysis that can simplify the diverse and complex factors in the observed variables by uniting factors or dimensions that are interconnected or have correlations in a new data structure that has smaller factors. So the variables in one factor have a high correlation, while the correlation with the variables in other factors is relatively low. Each group of variables represents a basic construct called a factor. To increase the interpretability of factors, a transformation must be carried out on the loading matrix. In this process, three assumptions are used, namely the Kaiser-Meyer-Olkin (KMO), the Bartlett Test of Sphericity, and the Anti-Image Correlation (MSA).

KMO is a test carried out to determine the appropriateness of a factor analysis to be carried out. The KMO test scale ranges from 0 to 1. If the calculated KMO value is lower than 0.5, then factor analysis is not feasible. Meanwhile, if the calculated KMO value is greater than 0.5, then factor analysis is feasible.

Bartlett's test of sphericity can determine whether these variables have a correlation or not by looking at the significance level value obtained. If the sig value is below alpha 0.05, then the correlation between variables is low, so factor analysis cannot continue. Conversely, if the sig value is less than 0.05, then the correlation between variables is high and the factor analysis process can be continued.

MSA is a test carried out to measure the sampling adequacy of each variable. The condition for accepting the MSA test is that if the MSA value is above 0.5, then the variable can be predicted and can be analyzed further. Meanwhile, if the MSA value obtained is below 0.5, then this variable cannot be predicted and analyzed further, so this variable must be eliminated.

3. *Structural Equation Model (SEM)*

The final analysis method used was the structural equation model (SEM) using the linear structural model (LISREL) via second-order confirmatory factor analysis (2nd-order CFA). The first level of analysis is carried out from the aspect latent construct to its indicators, and the second level of analysis is carried out from the latent construct to its aspect constructs (Latan, 2012). These statistics show how well the model fits by looking at the root mean square error of approximation (RMSEA), the comparative improvement index (CFI), the non-normed fit index (NNFI), and the incremental fit index (IFI). They were first used by Batinic, Wolff, and Haupt (2007). The X2 test was also used to test the suitability of the model. RMSEA values less than 0.05 indicate good fit, and values as high as 0.08 represent acceptable estimation error. CFI/NNFI and IFI differ on a 0 to 1 continuum, where values greater than 0.90 are acceptable for the model and 0.95 fits the data to the model excellently. In order to perform the 2nd-order CFA test, it was necessary to look at the factor loading values (>0.5) and the calculated t value (>1.96). A factor loading weight of 0.50 or more is considered to have strong enough validity to explain the latent construct. The weakest acceptable factor loading is 0.40. A construct that has good reliability is one whose construct reliability (CR) value is ≥ 0.70 and whose variance extracted value is ≥ 0.50.

Result and Discussion

The study commenced by examining various pieces of literature pertaining to the conceptualization of attitudes, attitudes towards science, and scientific attitudes. During this step, data is collected on attitudes, which are a crucial element of the affective aspect and a significant learning outcome for students in the field of chemistry. The attitudes in question can be categorized into two groups: attitudes towards scientific material and attitudes towards learning chemistry in a scientific manner. The results of the FGD agreed on the components of a scientific attitude that were priorities for development in the chemistry learning process chosen by the discussion participants, namely honesty, responsibility, and cooperation.

An honest attitude was chosen because an honest attitude is one of the national characteristics reflected in Pancasila, which is included in the values of just and civilized humanity. Honest behavior underlies all other commendable behavior. Therefore, everyone, including students, must possess honest character because it will serve as a foundation for their future lives. Honesty means stating what is, being open and consistent between what is said and done (integrity), being brave because it is true, being trustworthy (trustworthiness), and not cheating (Samani and Haryanto, 2012).

The attitude of responsibility was selected due to its inclusion among the various attitudes that are esteemed in character education. Responsibility refers to an individual's disposition and conduct in fulfilling their assigned tasks and obligations. Responsibility entails exercising self-discipline, effectively doing duties both independently and collaboratively, and demonstrating a strong sense of accountability.

A cooperative mindset was selected due to the essential nature of collaboration in research. Collaboration among students is a crucial component in cultivating social aptitude and enhancing communication proficiency. Collaborative tasks and collective assignments not only enhance interpersonal skills, but also facilitate the exploration of a wide range of ideas and perspectives, hence fostering an enhanced learning environment. This partnership additionally enables students to cultivate dispute resolution abilities and foster an appreciation for diversity, which are crucial elements of cognitive and interpersonal development.

The instruments used to evaluate scientific attitudes throughout the initial design phase, through methods such as observation, self-assessment, and peer assessment, did not have an equal number of indicators and items. The purpose of assessment by observation is to minimize the number of items, as the teacher needs to observe multiple indicators for a class size ranging from 30 to 36 students.

The content validation process involved 5 experts who assessed the content of the grid, instrument, and rubric of the scientific attitude assessment. Based on their evaluation, conclusions were drawn regarding the items of the assessment instrument for each form of the instrument. The data analysis of the scientific attitude evaluation instrument for self-assessment demonstrated that all items were found to be legitimate during the content validation process. The content validation results using the Aiken test yielded an average Aiken score of 0.82 for all items in the instrument. The Aiken test value indicates that the produced instrument possesses good content validity, affirming that the content of the self-assessment tool is legitimate and appropriate for evaluating pupils.

Construct validity testing involved research subjects of 250 students selected using random techniques from 4 high schools (SMA). The main reason for selecting a sample of 250 in this study was to increase the reliability of the analysis results, provide greater statistical power, and increase the external validity of the research findings. With a large sample, random fluctuations can be reduced, providing stability to the analysis results. This also increases the ability of the analysis to detect differences and relationships between variables. Additionally, a large sample better reflects the diversity of the population, increasing the external validity of the findings. The selection of a large sample also allows for subgroup analyzes and testing of the stability of the factority model over time. The selected sample still represents the desired population so that the research results can be applied more widely.

The scientific attitude instrument studied consisted of 15 items reflecting 3 factors, namely: honesty (5 items), responsibility (5 items), and cooperation (5 items). Likert scale with four answer categories, namely strongly disagree 1, disagree 2, disagree 3, agree 4 and strongly agree 5. Indicators that reflect each factor are presented in Table 2.

Table 2. Scientific Attitude Instrument Indicators

Factor	Indicator	Question Item Number
Honesty	- Avoiding acts of plagiarism - Admiting your mistakes or shortcomings - Writing down data according to the results of observations	1.0 2.3 3.5
Responsibility	- Preparing or designing experimental equipment - Cleaning experimental equipment - Returning test equipment - Being aware of your obligations	6.7 8.0 9.0 10.0
Cooperation	- Being active in group work - Asking for opinions or help - Looking for ways to resolve differences of opinion - Discussing the results of the experiment	11.0 12.0 13.14 15.0

The results of the Kaiser Meyer Olkin Measure of Sampling (KMO) factor analysis assumption test and the Bartlett Test of Sphericity are measured by the SPSS presented by Table 3.

Table 3. KMO and Bartlett's Test values

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.939
Bartlett's Test of Sphericity	Approx. Chi-Square	1407.173
	df	105
	Sig.	.000

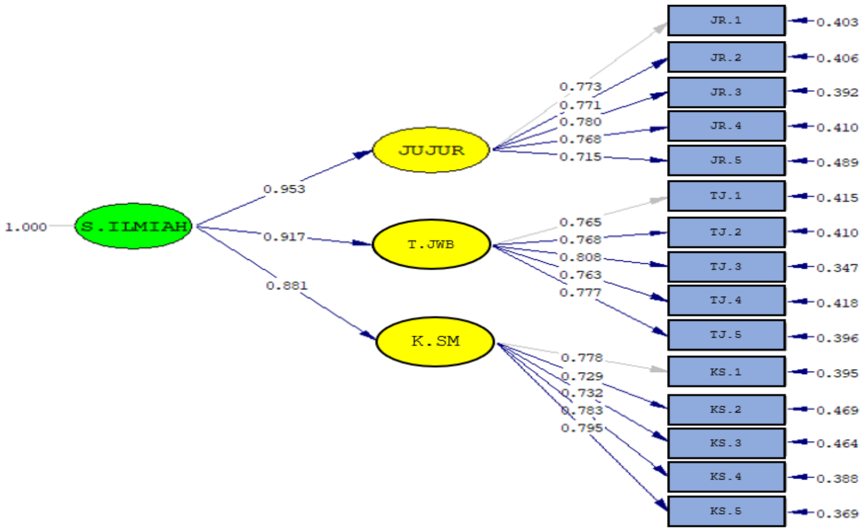
The second factor analysis assumption is the Kaiser Meyer Olkin of Sampling (KMO). KMO is a comparison index of the distance between the correlation coefficient and the partial correlation. The KMO value is considered sufficient if it is greater than 0.5. According to Santoso (2004), the KMO and Bartlett Test numbers must have a value above 0.5, and the significant value must be below 0.005. The research results show that the Kaiser Meyer Olkin Measure of Sampling value is 0.939. Thus, the KMO requirements meet the requirements because it has a value above 0.5 and close to 1. From the table above, it can also be seen that the results of calculating the Barlett Test of Spehricity value are 1407.173, with a significance of 0.000. Thus, the Barlett Test of Spehricity meets the requirements because the significance is below 0.05 (5%). The results of the third Factor Analysis Assumption are the MSA (Anti Image Correlation) value which is marked with an "a" in Table 4.

Table 4. Anti Image Correlation

Anti-image Correlation	JR1	JR1	JR2	JR3	JR4	JR5	TJ1	TJ2	TJ3	TJ4	TJ5	KS1	KS2	KS3	KS4	KS5
	JR1	.942[a]														
	JR2		.951[a]													
	JR3			.967[a]												
	JR4				.970[a]											
	JR5					.953[a]										
	TJ1						.928[a]									
	TJ2							.904[a]								
	TJ3								.935[a]							
	TJ4									.921[a]						
	TJ5										.947[a]					
	KS1											.938[a]				
	KS2												.938[a]			
	KS3													.932[a]		
	KS4														.929[a]	
	KS5															.939[a]

a. Measures of Sampling Adequacy (MSA)

The table above shows that the 15 variables tested meet the MSA requirements, namely above 0.5, so they can be used for further testing. From the results of the factor analysis tests that have been obtained, it can be concluded that all the variables used as data in this research have met the requirements for further testing. The final analysis using the Linear Structural Model (LISREL) program and the Structural Equation Model (SEM) showed that each item had been put into the right factor based on the given indicators. The magnitude of the loading factor presented in Figure 1 shows that each instrument item used to construct the scientific attitude variable has a value greater than 0.5. Thus, it can be said that all the items that have been developed are in accordance with the specified indicators and have strong enough validity to explain each factor in building a scientific attitude instrument.



Chi-Square=99.11, df=87, P-value=0.17661, RMSEA=0.031

Figure 1. SLF Value based on Each Indicator

A high standardized loading factor (SLF) value is indicative of good convergent validity. Good convergent validity of a measurement instrument includes several key characteristics that show a strong relationship between the instrument and other instruments that measure similar constructs. First, the instruments being measured should show a positive and significant correlation with each other. Good convergent validity means that the items on the instrument really do measure the same or similar constructs. Satisfactory Confirmatory Factor Analysis (CFA) results show this. In addition, high factor loading values on the CFA reflect a strong relationship between the items and the construct being measured. High reliability is also an important factor, showing the consistency of the instrument in measuring the construct over time. Theoretical precision, where each item fits within the underlying conceptual framework, is also important to strengthen convergent validity. Finally, comparison of results with the literature or similar instruments can strengthen convergent validity by linking the instrument's findings to previous research. Through these characteristics, measurement instruments can be relied on to measure the intended construct and are in accordance with the underlying theory. Hair (2010:678) suggests an SLF value of ≥ 0.5. The measure of construct reliability (CR) is also a determining indicator that shows whether convergent validity is good or not. Hair (2010:679) states that a CR value ≥ 0.7 includes good reliability, while a CR value between 0.6 and 0.7 includes acceptable reliability, provided that the indicator variables show good validity. Meanwhile, Hair (2010:679) states that an AVE value ≥ 0.5 indicates adequate convergence. The data regarding the SLF value of each latent variable is presented in Table 5.

Table 5. SLF Values Based on Indicators for Each Latent Variable

Dimensions or Latent Variables	Indicator or Item	SLF
Honesty	JR1	0.773
	JR2	0.771
	JR3	0.780
	JR4	0.768
	JR5	0.715
Responsibility	TJ1	0.765
	TJ2	0.768
	TJ3	0.808
	TJ4	0.763
	TJ5	0.777
Cooperation	KS1	0.778
	KS2	0.729
	KS3	0.732
	KS4	0.783
	KS5	0.795
Scientific Attitude	Honesty	0.953
	Responsibility	0.917
	Cooperation	0.881

Based on Table 5, it can be concluded: In the HONEST dimension there are 5 indicators. It is known that all SLF values are > 0.5, which means the indicators in HONEST are valid. In the RESPONSIBILITY dimension there are 5 indicators. It is known that all SLF values are > 0.5, which means the indicators in RESPONSIBILITY are valid. In the COOPERATION dimension there are 5 indicators. It is known that all SLF values are > 0.5, which means the indicators in COOPERATION are valid. In the latent variable SCIENTIFIC ATTITUDE there are 3 dimensions. It is known that all SLF values are > 0.5, which means that the dimensions of SCIENTIFIC ATTITUDE are valid. Data regarding Average variance extracted (AVE) and Construct Reliability (CR) values are presented in table 6.

Table 6. AVE and CR values

Dimensions or Latent Variables	Indicator or Item	SLF	Error	SLF^2	AVE	CR
HONESTY	JR1	0.773	0.403	0.597	0.580	0.873
	JR2	0.771	0.406	0.594		
	JR3	0.780	0.392	0.608		
	JR4	0.768	0.410	0.590		
	JR5	0.715	0.489	0.511		
RESPONSIBILITY	TJ1	0.765	0.415	0.585	0.603	0.883
	TJ2	0.768	0.410	0.590		
	TJ3	0.808	0.347	0.653		
	TJ4	0.763	0.418	0.582		
	TJ5	0.777	0.396	0.604		
COOPERATION	KS1	0.778	0.395	0.605	0.583	0.875
	KS2	0.729	0.469	0.531		
	KS3	0.732	0.464	0.536		
	KS4	0.783	0.388	0.612		
	KS5	0.795	0.369	0.631		
SCIENTIFIC ATTITUDE	HONESTY	0.953	0.093	0.907	0.841	0.941
	RESPONSIBILITY	0.917	0.160	0.840		
	COOPERATION	0.881	0.224	0.776		

From the AVE measure, the AVE value is known; it is known that all AVE values are > 0.5, which means that it meets the characteristics of good convergent validity based on the AVE measure. Meanwhile, based on the CR value, all CR values are > 0.7, which means that they meet the characteristics of good convergent validity based on the CR measure. Convergent validity, which is measured through average variance extracted (AVE), is a central criterion in evaluating the quality of construction measurement instruments. A high AVE, around 0.50 or more, indicates that the construct in question effectively explains the majority of the variance of the items associated with it. The dominance of the construct in explaining the variance of the items supports the accuracy of the construct measurement. The success of the instrument in reflecting the desired dimensions can also be strengthened through the consistency of AVE results with previous research findings or literature standards. In addition, a comparison between AVE and composite reliability (CR) can provide an idea of construct reliability, with higher CR values indicating that most of the variance in the items is explained by the construct. Critical analysis of the items, including comparisons with item loadings on construct factors, provided additional insight into the contribution of each item to overall convergent validity. Thus, researchers can ensure that the measurement instrument effectively achieves convergent validity and reflects the intended dimensions. Below is presented data regarding the Overall Model Fit Test data.

Table 7. Overall Model Fit Test

Match Size	Value	Benchmark Value	Model Fit to Data
RMSEA	0,031	< 0.1	Yes
P-Value	0.17661	> 0.05	Yes
RMR	0.05277	< 0.1	Yes
SRMR	0.03578	< 0.1	Yes
NFI	0.9291	> 0.9	Yes
RFI	0.9144	> 0.9	Yes

Based on Table 7, the results show that the SEM model as a whole has good capabilities in terms of matching sample data (Good Fit).

This research is simillar to research conducted by Research conducted by Suryani (2021) has developed a scientific attitude assessment instrument for learning through a research exercise model in elementary schools. This instrument is valid, reliable, and practical to use. The research findings indicate that this instrument effectively evaluates students' scientific attitudes, including aspects of curiosity, critical thinking, openness, honesty, and objectivity.

Wahyuningtyas (2021) conducted research to develop a scientific attitude assessment instrument using observational techniques on the topic of reaction rates. This instrument is valid and reliable, with a reliability score of 1.000 (indicating very high reliability) across all components of scientific attitude. The research results demonstrate that this instrument is capable of assessing students' scientific attitudes in a detailed and objective manner during laboratory exercises.

Siddiq (2021) conducted research to develop a valid and reliable performance assessment instrument for evaluating students' performance in the concentration's effect on reaction rate laboratory exercises. This instrument can reveal students' performance across various aspects, such as experiment planning, data analysis, and drawing conclusions.

Conclusion

This research produces a scientific attitude assessment instrument for chemistry learning. The results of content validation using the Aiken test obtained an average Aiken value of 0.82. The Aiken test value indicates that the instrument developed is in the good category in terms of content validity. The Kaiser Meyer-Olkin Measure of Sampling value is 0.939, and the calculated value of the Barlett Test of Spehricity is 1407.173 with a significance of 0.000. The instrument for assessing students' scientific attitudes shows that the theoretical model of the social science attitudes variable that was designed is in fact in accordance with the empirical data. The instrument developed has strong validity (> 0.5). The scientific attitude instrument can be reflected in its three constituent aspects, namely honesty, responsibility, and cooperation. The most dominant factor in this instrument is the honesty factor, with a loading factor value of 0.953, while the weakest factor is cooperation, with a loading factor value of 0.881. The SEM model as a whole has good capabilities in terms of matching sample data (good fit).

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