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Reviewing of Indonesian students' scientific communication skills: A structural equation modeling analysis

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ABSTRACT

To ensure the success of science learning oriented to higher order thinking skills, especially scientific communication skills (SCS), valid and effective instruments are needed. The existing instruments, although helpful, are still too general and have not touched the socio-cultural context. Therefore, we developed an instrument to measure SCS according to the characteristics of students in Indonesia. This study tested the validity, reliability and assumptions of the hypothetical model of the scientific communication skills inventory (SCSI) instrument developed. This study involved 1,287 students in Indonesia. The test was carried out through confirmatory factor analysis with structural equation modelling (SEM) using AMOS version 21. The results of the analysis show that the reliability of the instrument based on Cronbach's alpha coefficient is 0.720. The convergent validity test detected one item of the oral presentation indicator as invalid and the discriminant validity test confirmed that all instrument items were declared valid. The goodness of fit test shows all scores according to the recommended standard criteria so that SCSI can be used to identify the SCS ability profile of students in Indonesia. For further research, we recommend the development of a learning model that prioritizes the context of social issues to grow students' SCS.

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1. INTRODUCTION

Scientific communication skills (SCS) are life skills competencies that need to be mastered by the world community in the 21st century in facing the impact of accelerating changes in science and technology [1]. Spektor-Levy, Eylon, and Scherz [2] stated that SCS includes six skill indicators, namely information retrieval; scientific reading; listening and observing; scientific writing; information representation; and knowledge presentation. All skill indicators in SCS must be developed in an integrated manner [2]. Currently, the development of SCS in Indonesia is still focusing on improving communication skills indicators [3]–[5]. However, even though the development of communication skills is consistently carried out, students still have difficulty improving communication skills [3], [4], [6]. The same thing is reinforced by [7] that the non-verbal communication skills of the majority of Indonesian students are in the intermediate category and the criteria for verbal communication do not meet the standards. SCS competence has been proven to be effective in improving learning performance oriented to higher order thinking skills [2], [8], [9].

This suggests that potential SCS competencies can support the creative thinking abilities of Indonesian students which are currently still relatively low [10]. Efforts to provide empirical evidence that the development of SCS competence actually occurs in learning, it is necessary to have an SCS instrument used to assess the process. The SCS instrument globally has been widely used in international published research, including assessing the communication skills of junior high school students in South Korea [11], evaluate the application of SCS as an instruction in improving scientific literacy performance [2], investigated the development of students' scientific communication skills in science learning in the United Kingdom [12], and develop scientific communication skills by applying SCS as a learning model, content, and practice [13].

Problems that occur in Indonesia based on literature searches show that so far there is no SCS instrument that can be used to measure the SCS competency profile in students [6], [14]–[24]. This implies that it is necessary to develop a valid and effective SCS instrument based on the characteristics of junior high school students in Indonesia. Testing the quality aspects of the instrument through the analysis of validity and reliability is an important activity before the instrument is used as a data collection tool [25], especially if the research findings are followed up as evaluation material in practice at an advanced stage [26]. Validity is defined as the instrument's ability to measure something to be measured [27]. The most common validity of concern includes content validity, criterion related validity, and construct validity [28], but there is still other validity in the measurement model, namely convergent validity and discriminant validity. Convergent validity is related to the manifest variables of the construct and discriminant validity is related to the manifest variables of different constructs [29]. In this study, convergent validity and discriminant validity were tested through confirmatory factor analysis (CFA) using software analysis of moment structures (AMOS) [30].

Furthermore, Heale and Twycross [31] explained reliability as the degree of consistency of the instrument when measurements are made at different times. This means that reliability refers to the stability of research findings [32]. Cronbach's alpha is the most famous statistical analysis that is widely used by researchers when testing the level of reliability [33]. Therefore, this study tested the instrument's reliability index using the Cronbach's Alpha coefficient. This research is not only aimed at testing the validity and reliability of the developed scientific communication skills inventory (SCSI) instrument, also tested other assumptions using structural equation modeling (SEM) with AMOS software. SEM is believed to be the most popular analytical method, especially for analyzing data obtained through questionnaires [34]. To produce a good quality SCSI instrument, the research questions are: i) Does the AMOS output evidence support the validity of the SCSI instrument developed for use in the advanced research phase?; ii) Does the evidence of Cronbach's Alpha coefficient support the reliability of the SCSI instrument that was developed for use in the advanced research phase?; iii) Does the AMOS output evidence based on the SEM assumption test support the SCSI instrument developed for use in the advanced research phase?

2. RESEARCH METHOD

2.1. Design

This study uses a quantitative descriptive survey design which includes several research steps, namely determining research problems, making survey designs, developing survey instruments, determining samples, conducting survey-tests, collecting data, checking data, coding data, data entry, processing and analyzing data, interpretation of data, as well as making conclusions and recommendations [35]. As for the administrative technique, the researcher first applied for permission to the school leadership before the students responded to the answers in the developed SCSI instrument. Natural science subject teachers at each school assist researchers related to the technical process, namely providing explanations about the research objectives and how to fill out the developed SCSI instrument. Furthermore, respondents responded online on the SCSI instrument sheet which was developed through the google form platform.

2.2. Sample

The research population includes all 8th grade students of public and private junior high schools in Indonesia, amounting to 3,348,420 students. The research sample was taken by purposive sampling technique. The samples involved in this research study were 1,287 students with details of 749 students from the western part of Indonesia, 396 students from the central part of Indonesia, and 142 students from the eastern part of Indonesia.

2.3. Instrument

The SCSI instrument which was developed according to the characteristics of junior high school students in Indonesia is a modification of the researcher based on the study of [1]. The SCSI instrument developed consists of six variables and each variable is divided into three indicators, so that there are 18 indicators in total. The indicator items are described in the form of positive or negative statement descriptions that are measured using a Likert scale with five assessment answer choices, namely "never", "seldom",

"sometimes", "often", and "always". The preparation of positive and negative statements aims to make the respondent really read all the statements carefully and answer correctly. The scoring system given for each student's response can be seen in Table 1.

Table 1. Answering response scoring system of the developed SCSI instrument

Alternative	Scoring	
Response answer	Positive statement	Negative statement
Never	1	5
Seldom	2	4
Sometimes	3	3
Often	4	2
Always	5	1

2.4. Data analysis

The research data were analyzed using SEM with AMOS software which included testing for normality and data outliers, testing validity, and testing model suitability. The reliability index uses Cronbach's Alpha coefficient. Data normality analysis was carried out by evaluating the critical ratio (CR) value of the AMOS assessment of normality output. Research data is said to be normally distributed if the value shown by CR is in the range of $-2.58 \leq CR \leq 2.58$ [36].

The test of data outliers is carried out through analysis based on the output of AMOS observations farthest from the centroid, namely by looking at the value indicated by the mahalanobis d-squared. The data is said to be excluding outliers if the value of the mahalanobis distance is not greater than the statistical value of the chi square at a significance level of $p<0.001$ with a degree of freedom according to the number of indicators [36]. Validity analysis was carried out through convergent validity and discriminant validity tests. Convergent validity testing seen from the output of AMOS regression weights with measurement criteria is said to be valid if the coefficient of the indicator variable is greater than twice the value of the standard error or critical ratio (CR)>2.S.E, while the discriminant validity test is known from the AMOS covariances output with valid criteria if the probability value (P)<0.05 [36]. Cronbach's Alpha is the most commonly used instrument reliability index measurement by researchers [37]. Therefore, in this study the reliability index of the SCSI instrument was analyzed using Cronbach's Alpha coefficient. The recommended minimum coefficient of Cronbach's Alpha is 0.5–0.8 [38].

The goodness of fit test model was analyzed based on the output of the AMOS model fit summary by comparing the acquisition of AMOS values and acceptable criteria parameters. In this regard, the output values of concern include the value of CMIN, goodness of fit index (GFI), adjusted goodness of fit index (AGFI), Tucker Lewis Index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA), and HOELTER 0.05 and HOELTER 0.01. The goodness of fit test criteria using the default model CMIN value parameters are in the range of values of CMIN saturated model and CMIN independence model; the value indicated by GFI and AGFI≥0.90; TLI and CFI values are in the range of 0.00–1.00; RMSEA value shows ≤0.08; and HOELTER≥200 [39].

3. RESULTS AND DISCUSSION

3.1. Normality analysis of data items developed SCSI instrument

Analyzing the level of normality of research data is important so that it can be seen that the distribution of data distribution is normal or not so that it strengthens the decision to follow up the instrument at the next stage [40]. Table 2 presents the output of AMOS regression weights to see the results of the normality analysis of the data items of the developed SCSI instrument. Based on the evaluation results in Table 2, it can be explained that the research data items of the developed SCSI instrument have CR value with a range of -0.949 to 1.257. Research data analyzed using the AMOS program [36] can be stated to be normally distributed if the data from the AMOS regression weights output has a CR value that is in the range of $-2.58 \leq CR \leq 2.58$. This means that it can be represented that the CR value of the developed SCSI instrument data items is in the data normality decision range, which is between $-2.58 \leq CR \leq 2.58$ so that it can be stated that the data items of the developed SCSI instrument are normally distributed [36]. Thus, based on the results of the normality analysis of research data, it can be concluded that the items of the SCSI instrument developed according to the characteristics of junior high school students in Indonesia are normally distributed and suitable for use in the next research stage.

Table 2. Results of normality data items of the developed SCSI instrument

Variable	Minimum	Maximum	Critical ratio
Oral_Presentation	1.000	5.000	-1.830
Multimedia	1.000	5.000	-1.499
Poster	1.000	5.000	-1.074
Table	1.000	5.000	-1.275
Scheme	1.000	5.000	-1.854
Graph	1.000	5.000	-1.754
Scientific_Essay	1.000	5.000	0.510
Report_Writing	1.000	5.000	-1.493
Abstract	1.000	5.000	-1.779
Lecture	1.000	5.000	1.257
Demonstration	1.000	5.000	-1.667
Video	1.000	5.000	-1.685
Article	1.000	5.000	-1.445
Textbook	1.000	5.000	-1.352
Report	1.000	5.000	-1.146
Library	1.000	5.000	-1.488
Electronic_Database	1.000	5.000	1.206
Experts	1.000	5.000	-0.949

3.2. Outliers analysis of data items developed SCSI instrument

Outliers data reveal that data has different characteristics when compared to other data which generally appears in the form of extreme values [41]. The data outliers in this study were analyzed based on the output of AMOS observations farthest from the centroid through the value indicated by the mahalanobis d-squared. Research data is said to be excluding outliers [36], if the value indicated by the mahalanobis distance is not greater than the chi square statistical value at a significance level of $p < 0.001$ with a degree of freedom according to the number of indicators. Meanwhile, in this study, the statistical value of chi square on the value of the mahalanobis distance square at a significance level of $p < 0.001$ with a degree of freedom of 18 research indicators obtained a value of 42.312. So, if in this study there is a mahalanobis distance value greater than 42.312 it can be said that the data has outliers [36]. Table 3 presents the output of AMOS observations farthest from the centroid to find out the results of the outliers' analysis of research data items of the developed SCSI instrument.

Based on the evaluation results in Table 3, it is revealed that the research data has the smallest d-squared mahalanobis value of 32.950, namely at the observation number 942 and the largest d-squared mahalanobis value is 42.932 at the observation number 1,208. Most of the research data was detected to have a d-squared mahalanobis value smaller than 42.312 and there are two research data that have a d-squared mahalanobis value greater than 42.312 namely observation data number 1,176 with a d-squared mahalanobis value 42.467 and observation number 1,208 with a d-squared mahalanobis value 42.932. This represents that most of the data in this study can be explained not to contain outliers [36]. This representation is strengthened by the data of the d-squared mahalanobis value of 42.467 and 42.932 when compared with the chi-square statistical value of the mahalanobis distance square value at a significance level of $p<0.001$ of 42.312 which can be explained as a value that is not too extreme. Thus, it can be understood that the overall data of this study do not have different characteristics.

Basically, it can be emphasized that data containing outliers according to Arbuckle [36] needs to be removed because it can affect the results of data normality being unfulfilled. However, in this study, it has been confirmed through normality analysis that the data has a normal distribution as seen in Table 2, so that the researcher does not need to delete the observation numbers 1,176 and 1,208 as data that is described as containing outliers. Furthermore, Ferdinand [42] provided support that if the results of the analysis show outliers, the data does not have to be removed or deleted because the data displayed describes the actual research situation. This means that the data observation numbers 1,176 and 1,208 can be decided to continue to be used as samples in the study. Based on the explanation of the results of the outlier analysis of the data, it can be concluded that the SCSI instrument items developed according to the characteristics of junior high school students in Indonesia do not contain outliers and are suitable for use in the next research stage.

Table 3. Outlier data items results of the developed SCSI instrument

Observation number (1)	Mahalanobis d-squared (1)	Observation number (2)	Mahalanobis d-squared (2)
1,208	42.932	386	37.293
1,176	42.467	992	37.239
920	41.700	885	37.078
1,286	41.504	699	36.771
968	41.496	963	36.761
1,025	41.485	1,080	36.605
935	41.405	1,167	36.222
1,233	41.159	1,162	36.173
804	40.964	575	36.157
1,122	40.428	584	36.147
908	40.415	1,224	36.087
894	39.840	1,234	35.927
1,177	39.775	1,207	35.822
997	39.603	1,004	35.778
865	39.563	1,046	35.485
752	39.432	257	35.342
1,127	39.297	281	35.298
838	39.113	837	35.257
1,112	39.015	354	34.998
1,118	38.959	1,266	34.973
465	38.896	1,274	34.917
1,270	38.894	1,115	34.833
1,150	38.868	668	34.778
1,061	38.808	1,165	34.543
893	38.457	1,283	34.507
1,031	38.396	814	34.437
1,193	38.379	261	34.359
1,018	38.333	924	34.138
1,055	38.238	990	34.138
1,111	38.146	68	33.978
1,191	38.144	1,210	33.671
308	38.091	72	33.582
1,098	38.047	1,260	33.323
737	38.018	764	33.300
1,022	37.932	124	33.300
1,178	37.920	1,159	33.113
1,247	37.899	80	33.108
1,222	37.872	157	33.068
755	37.462	998	33.060
857	37.385	942	32.950

3.3. Analysis of the item's validity of the developed SCSI instrument

Validity testing in this study was carried out by taking into account the results of the analysis of convergent validity and discriminant validity tests. The convergent validity test is seen from the AMOS regression weights output while the discriminant validity test is based on the AMOS covariances output. Convergent validity provides an overview of the ability of each indicator to measure the dimensions of the concept to be measured and explains the relationship between the manifest variable and its latent variable [43]. Research data based on the measurement of convergent validity can be declared valid if the coefficient of the indicator variable shows a value greater than twice the standard error value or C.R>2.S.E [36]. Table 4 presents the results of the analysis of the convergent validity of the items developed for the SCSI instrument.

Based on the evaluation results in Table 4, it can be explained that most of the manifest variables have indicator variable coefficients greater than twice the standard error value or detected C.R>2.S.E values. However, the CR value in the manifest oral presentation variable is known to show a value less than twice the standard error value. This shows that most of the manifest variables in the data of this study are able to explain the latent variables and can be declared "valid" while the manifest oral presentation variables are unable to explain the latent variables of knowledge presentation and are declared "invalid" [36], [43].

Based on the convergent validity test, it can be concluded that from all the items of the SCSI instrument developed in this study, there were 17 items that were declared "valid" while one item, namely the oral presentation, was described as "invalid". The description of the manifest oral presentation variable is "*I find it difficult when the teacher asks me to explain the experimental findings or observations in front of the class, even though my friends support me*." Thus, the SCSI instrument which was developed according to the characteristics of junior high school students in Indonesia is suitable for use in the next stage of research with the important note of building a learning flow that supports oral presentation indicators. Discriminant validity is carried out to test two latent variables that have differences and each latent variable is independent

and analyzes the relationship between two different latent variables when they are simultaneously in the same study [43]. Research data based on the measurement of discriminant validity according to Arbuckle [36] can be declared valid if the probability (P) on the AMOS covariances output shows a value <0.05. Table 5 presents the results of the analysis of the discriminant validity of the SCSI instrument items developed according to the characteristics of junior high school students in Indonesia.

Based on the evaluation results in Table 5, it can be explained that the overall SCSI instrument items developed show a probability value of ***. The *** sign in statistics is defined as the number 0.000 which means <0.05. This reveals that the discriminant validity test of the developed SCSI instrument items can be declared "valid" [36]. Through the evaluation results in Table 5, it can also be identified that all manifest variables are able to explain the latent variables or with other explanations that all instrument indicators are able to explain the variables. Thus, it can be emphasized that the SCSI instrument items developed according to the characteristics of junior high school students in Indonesia are valid and appropriate to be used as a data collection tool at the advanced research stage.

Table 4. Convergent validity results of the developed SCSI instruments

			S.E.	C.R.	P	Decision
Experts	<---	Information_Retrieval				Valid
Electronic_Database	<---	Information_Retrieval	0.128	5.859	***	Valid
Library	<---	Information_Retrieval	0.211	7.707	***	Valid
Report	<---	Scientific_Reading				Valid
Textbook	<---	Scientific_Reading	0.122	11.089	***	Valid
Article	<---	Scientific_Reading	0.094	9.265	***	Valid
Video	<---	Listening_Observing				Valid
Demonstration	<---	Listening_Observing	0.060	9.356	***	Valid
Lecture	<---	Listening_Observing	0.053	9.874	***	Valid
Abstract	<---	Scientific_Writing				Valid
Report_Writing	<---	Scientific_Writing	0.443	5.754	***	Valid
Scientific_Essay	<---	Scientific_Writing	0.209	4.309	***	Valid
Graph	<---	Information_Representation				Valid
Scheme	<---	Information_Representation	0.087	9.127	***	Valid
Table	<---	Information_Representation	0.094	10.626	***	Valid
Poster	<---	Knowledge_Presentation				Valid
Multimedia	<---	Knowledge Presentation	0.145	8.834	***	Valid
Oral_Presentation	<---	Knowledge_Presentation	0.074	-0.993	0.321	Invalid

Table 5. Results discriminant validity of the developed SCSI instrument

			Estimate	S.E.	C.R.	P	Decision
Information_Retrieval	←>	Scientific_Reading	0.095	0.015	6.477	***	Valid
Information_Retrieval	←>	Listening_Observing	0.165	0.022	7.631	***	Valid
Information_Retrieval	←>	Scientific_Writing	0.052	0.011	4.715	***	Valid
Information_Retrieval	←>	Information_Representation	0.102	0.016	6.513	***	Valid
Information_Retrieval	←>	Knowledge_Presentation	0.077	0.015	5.287	***	Valid
Scientific_Reading	←>	Listening_Observing	0.241	0.024	10.020	***	Valid
Scientific_Reading	←>	Scientific_Writing	0.075	0.014	5.228	***	Valid
Scientific_Reading	←>	Information_Representation	0.087	0.015	5.911	***	Valid
Scientific_Reading	←>	Knowledge_Presentation	0.054	0.014	3.850	***	Valid
Listening_Observing	←>	Scientific_Writing	0.103	0.019	5.460	***	Valid
Listening_Observing	←>	Information_Representation	0.174	0.021	8.238	***	Valid
Listening_Observing	←>	Knowledge_Presentation	0.145	0.022	6.536	***	Valid
Scientific_Writing	←>	Information_Representation	0.070	0.014	5.093	***	Valid
Scientific_Writing	←>	Knowledge_Presentation	0.044	0.011	4.109	***	Valid
Information_Representation	←>	Knowledge_Presentation	0.202	0.025	8.131	***	Valid

3.4. Analysis of items reliability index of the developed SCSI instrument

The measurement of the reliability index of the SCSI instrument items developed in this study was carried out by taking into account the Cronbach Alpha coefficient value. The standard criteria for the reliability index can be accepted or declared reliable, if the minimum coefficient of Cronbach's Alpha shows a value in the range of 0.5-0.8 [38]. Table 6 presents the Cronbach Alpha coefficient values for the SCSI instrument developed. Based on Table 6, the Cronbach Alpha coefficient value of the developed SCSI instrument is 0.702. This means the developed SCSI instrument has Cronbach Alpha coefficient value which is in the Cronbach Alpha coefficient range of 0.5-0.8. This explains that the developed SCSI instrument items can be declared reliable [38]. Thus, it can be emphasized that the SCSI instrument items developed are reliable and suitable to be used as data collection instruments at the advanced research stage.

Table 6. Reliability index of the developed SCSI instrument

Cronbach's Alpha	Cronbach's Alpha based on standardized items
0.702	0.701

3.5. Goodness of fit model items of the developed SCSI instrument

After measuring the model to obtain information on data normality, data outliers, convergent validity and discriminant validity, as well as the reliability index of the SCSI instrument, the next step is to analyze the goodness of fit model using SEM model analysis. SEM is a statistical technique that has the ability to analyze the pattern of relationships between latent constructs and their indicators, between one latent construct and another, and direct measurement errors [39]. The goodness of fit test analysis is carried out as an evaluation tool in order to determine that the model modified by the researcher can be accepted or rejected statistically [44]. Figure 1 presents the SEM measurement model proposed by the researcher.

The estimation results of the goodness of fit test of the SEM items model of the SCSI instrument developed in Figure 1 can be seen in more detail based on the output of the AMOS model fit summary by paying attention to measurements on the values of CMIN, GFI, AGFI, TLI, CFI, RMSEA, and HOELTER. The criteria for testing goodness of fit according to [39] described using the default model CMIN value parameter which is in the range of CMIN saturated model and CMIN independence model; the value indicated by GFI and AGFI ≥ 0.90; TLI and CFI values are in the range of 0.00 – 1.00; RMSEA value shows the number ≤ 0.08; and HOELTER ≥ 200. Table 7 presents the results of the structural analysis of the SEM items model of the SCSI instrument developed.

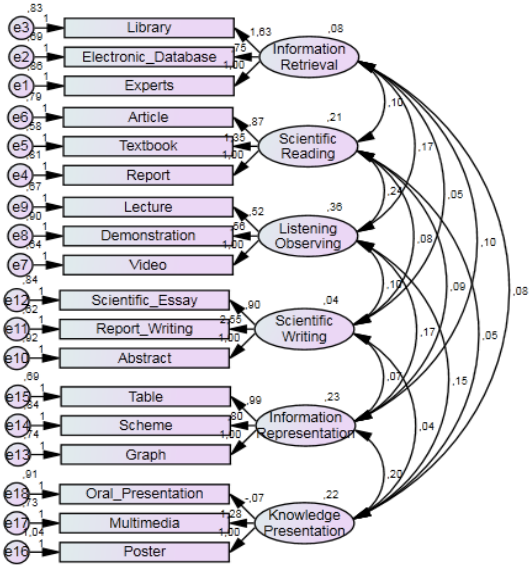

Figure 1. The structural equation modeling items of the developed SCSI instrument

Table 7. Goodness of fit test results of the developed SCSI instrument

Model	CMIN	GFI	AGFI	TLI	CFI	RMSEA	HOELTER	
							0.05	0.01
Default	866.174	0.921	0.888	0.621	0.702	0.07	218	236
Saturated	0.000	1.000	-	-	1.000	-	-	-
Independence	2660.611	0.731	0.699	0.000	0.000	0.113	89	96
Decision	Fit model	Fit model	Fit model	Fit model	Fit model	Fit model	Fit model	Fit model

Based on Table 7, it can be seen that the goodness of fit measurement data shows the values of CMIN, GFI, AGFI, TLI, CFI, RMSEA, and HOELTER according to the recommended test criteria [39]. The default CMIN value of the model of 866.174 has met the standard criteria, which is between the value of the CMIN saturated model of 0.000 and the CMIN independence model of 2660.611. The GFI value of 0.921 has met the specified standard, namely ≥0.90. The AGFI value of 0.888 indicates the results are in accordance

with the test criteria, namely ≥0.90. The TLI value of 0.621 has met the standard recommendation criteria, namely 0.00–1.00. The CFI value shows the number 0.702 also in accordance with the criteria, namely 0.00–1.00. The RMSEA value of 0.07 indicates conformity with the test standard, namely ≤0.08. The HOELTER values of 218 and 236 are also in accordance with the test criteria, namely ≥200. Referring to the evaluation results of the overall goodness of fit measurement, all indices show good model suitability and all values have met the fit criteria [39]. This means that the model proposed in this study is acceptable [36]. Thus, the new instrument model, namely the SEM items model of the SCSI instrument developed according to the characteristics of junior high school students in Indonesia, can be used in advanced research practice.

Overall, the findings of this study reveal that the SCSI instrument developed based on the characteristics of junior high school students in Indonesia in terms of validity, reliability, and the SEM measurement model shows evidence of valid, reliable criteria, and as a goodness of fit model so that the instrument can be used at the advanced research stage, especially to measure students' SCS ability in science learning. However, our research supports the implementation of the SCSI instrument in the context of Indonesian education to pay attention to differences in geographical location in Indonesia which includes urban, semi-urban and rural areas [45]. This is as the results of a literature search which reveal that there are differences in the scientific skills of Indonesian students in urban, semi-urban, and rural areas [46], [47]. Therefore, the quality of science learning that encourages the growth of SCS abilities in students in urban, semi-urban, and rural areas needs to be aligned.

Furthermore, the findings of this study specifically confirm the relationship between oral presentation indicators and the latent construct of knowledge presentation showing the estimated negative value of 0.07. This indicates that there is a weak relationship pattern between the oral presentation indicator and its latent construct or that the oral presentation indicator is unable to explain its latent construct [39]. This means that this study detects potential problems related to oral presentation skills in students' SCS competencies. This shows that the learning model that has so far developed in Indonesia has not been optimal in developing SCS abilities in students. Therefore, in future research practices, we recommend the development of learning models that support higher-order thinking skills, especially building SCS competencies in students. In this regard, we recommend the development of a learning model that prioritizes the context of social issues, especially social issues related to science, for example the problem of environmental pollution. This learning climate in the context of social issues encourages students' awareness to build conceptual change through the construction of existing concepts and to realize the creation of cooperative learning strategies. This is in line with that proposed by Leasa, Talakua, and Batlolona [48] that cooperative learning strategies have the potential to improve students' higher order thinking skills.

4. CONCLUSION

The results showed that the SCSI instrument developed in accordance with the characteristics of junior high school students in Indonesia was indicated to be valid and reliable and tested as a goodness of fit model so it was feasible to be used to measure students' SCS abilities. The SCSI instrument is an integral part of the quality of science learning and learning that supports the 21st century capabilities of Indonesia's young generation. Through the SCSI instrument, teachers and schools can make strategic efforts in developing future science curricula. The SCSI instrument can also be used as an ongoing assessment in mapping students' communication skills in science learning that supports higher-order thinking skills. In addition, the SCSI instrument will be an alternative assessment that has the potential to increase students' active involvement in the learning process and stimulate self-efficacy in scientific communication. This study has limited Cronbach's Alpha coefficient value of only 0.720, however, by modifying some items it can be increased to be higher. Further research needs to develop learning strategies/approaches/models along with learning tools that are synergistic with the growth of students' SCS.

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REFERENCES

[1] O. Spektor-Levy, B. S. Eylon, and Z. Scherz, "Teaching communication skills in science: Tracing teacher change," *Teaching and Teacher Education*, vol. 24, no. 2, pp. 462–477, Feb. 2008, doi: 10.1016/j.tate.2006.10.009.

[2] O. Spektor-Levy, B. S. Eylon, and Z. Scherz, "Teaching scientific communication skills in science studies: Does it make a difference?" *International Journal of Science and Mathematics Education*, vol. 7, no. 5, pp. 875–903, 2009, doi: 10.1007/s10763-009-9150-6.

[3] J. Suratno, W. S. Tonra, and Ardiana, "The effect of guided discovery learning on students' mathematical communication skill," in *AIP Conference Proceedings*, vol. 2194, 2019, doi: 10.1063/1.5139851.

[4] A. Fadli and Irwanto, "The effect of local wisdom-based ELSII learning model on the problem solving and communication skills of pre-service Islamic teachers," *International Journal of Instruction*, vol. 13, no. 1, pp. 731–746, Jan. 2020, doi: 10.29333/iji.2020.13147a.
[5] A. F. R. A. Ichsan, R. Adawiyah, and I. Wilujeng, "Analysis of the ability of students' communication skills and self-efficacy on science instruction," *Journal of Physics: Conference Series*, vol. 1440, no. 1, 2020, doi: 10.1088/1742-6596/1440/1/012088.
[6] M. D. Wulandari, S. Sarwi, and A. Yulianto, "Development of Discovery Learning Model Using Scientific Approach to Increase Student's Comprehension and Communication Skills," *Journal of Innovative Science Education*, vol. 7, no. 2, pp. 223–228, 2018.
[7] A. Haryanti and I. R. R. Suwarma, "Profile of junior high school students' communication skills in STEM-based science learning," (in Indonesian), *WaPFi (Wahana Pendidikan Fisika)*, vol. 3, no. 1, p. 49, Feb. 2018, doi: 10.17509/wapfi.v3i1.10940.
[8] J. A. Nielsen, "Arguing from Nature: The role of 'nature' in students' argumentations on a socio-scientific issue," *International Journal of Science Education*, vol. 34, no. 5, pp. 723–744, Mar. 2012, doi: 10.1080/09500693.2011.624135.
[9] S. Jeon and J.-H. Park, "Analysis of Relationships of Scientific Communication Skills, Science Process Skills, Logical Thinking Skills, and Academic Achievement Level of Elementary School Students," *Journal of The Korean Association for Research in Science Education*, vol. 34, no. 7, pp. 647–655, Oct. 2014, doi: 10.14697/jkase.2014.34.7.0647.
[10] M. Leasa, J. R. Batlolona, and M. Talakua, "Elementary students' creative thinking skills in science in the Maluku islands, Indonesia," *Creativity Studies*, vol. 14, no. 1, pp. 74–89, Mar. 2021, doi: 10.3846/cs.2021.11244.
[11] D. L. Zeidler, Y. Chung, J. Yoo, S. Im, and H. Lee, "Enhancing students' communication skills in the science classroom through socioscientific issues related papers," *International Journal of Science and Mathematics Education*, vol. 14, pp. 1–27, 2014.
[12] A. Rees and M. Wilkinson, "Scientific Communication Skills: The Transition From Further Education To Higher Education In The UK," *Journal of College Teaching & Learning (TLC)*, vol. 5, no. 9, Sep. 2008, doi: 10.19030/tlc.v5i9.1232.
[13] N. Kolesnikova and Y. V. Ridnaya, "Developing master's students scientific communication skills in the Russian and English languages: model, content, experiment," *Language and Culture*, no. 12, pp. 83–96, Dec. 2018, doi: 10.17223/24109266/12/8.
[14] N. Faizah, "Application of Guided Inquiry Learning to Improve Concepts and Skills Understanding Scientific Communication of High School Students Class X," (in Indonesian), Unpublished Thesis, Universitas Negeri Semarang, 2016.
[15] S. Samsuriadi and M. A. Imron, "The Effect of Think Pair Share (TPS) Learning Model With Problem Solving Approach on the Student's Math Communication in MA DA Jarowaru," *Malikussaleh Journal of Mathematics Learning (MJML)*, vol. 2, no. 1, Dec. 2019, doi: 10.29103/mjml.v2i1.2125.
[16] M. Zohrabi and H. Jafari, "The Role of Think-Pair-Share Interactional Activity on Improving Iranian EFL Learners' Willingness-To-Communicate," *Journal of Teaching English Language*, vol. 14, no. 1, pp. 153–182, 2020, doi: 10.22132/TEL.2020.106921.
[17] A. K. M. Faraj Allah, "The Impact of Employing The (Think -Pair -Share) Strategy to Gain Some Number Sense Skills and Mathematical Communication Skills Among Fifth Grade Students," *An-Najah University Journal of Research - Humanities*, vol. 31, no. 9, pp. 1663–1727, 2017, doi: 10.35552/0247-031-009-006.
[18] R. A. Desta, "Think pair share technique in teaching speaking skill," *Research in English and Education Journal*, vol. 2, no. 1, pp. 37–46, 2017.
[19] A. A. A. Raba, "The Influence of Think-Pair-Share (TPS) on Improving Students' Oral Communication Skills in EFL Classrooms," *Creative Education*, vol. 08, no. 01, pp. 12–23, 2017, doi: 10.4236/ce.2017.81002.
[20] O. B. Pramesti, S. Supeno, and S. Astutik, "The effect of guided inquiry learning model on scientific communication ability and physics learning outcomes of high school students," (in Indonesian), *Jurnal Ilmu Fisika dan Pembelajarannya (JIFP)*, vol. 4, no. 1, pp. 21–30, Jul. 2020, doi: 10.19109/jifp.v4i1.5612.
[21] E. Rosiani, Parmin, and M. Taufiq, "Cooperative Learning Model of Group Investigation Type On Students Critical Thinking Skill and Scientific Communication Skills," *Unnes Science Education Journal*, vol. 9, no. 1, pp. 392–402, 2020.
[22] S. Sugito, S. M. E. Susilowati, H. Hartono, and S. Supartono, "Enhancing Students' Communication Skills through Problem Posing and Presentation," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 6, no. 1, p. 17, Mar. 2017, doi: 10.11591/ijere.v6i1.6342.
[23] H. Pramono and N. Nana, "Efforts to improve cognitive ability and scientific communication of class X MIA 1 SMA Negeri 1 Ciamis students using the inquiry learning model," (in Indonesian), *Diffraction*, vol. 1, no. 1, pp. 1–10, 2019.
[24] R. S. Wicaksono, H. Susilo, and Sueb, "Implementation of Problem Based Learning Combined with Think Pair Share in Enhancing Students' Scientific Literacy and Communication Skill through Teaching Biology in English Course Peer teaching," *Journal of Physics: Conference Series*, vol. 1227, no. 1, p. 12005, Jun. 2019, doi: 10.1088/1742-6596/1227/1/012005.
[25] C. L. Kimberlin and A. G. Winterstein, "Validity and reliability of measurement instruments used in research," *American Journal of Health-System Pharmacy*, vol. 65, no. 23, pp. 2276–2284, Dec. 2008, doi: 10.2146/ajhp070364.
[26] H. Noble and J. Smith, "Issues of validity and reliability in qualitative research," *Evidence-Based Nursing*, vol. 18, no. 2, pp. 34–35, Feb. 2015, doi: 10.1136/eb-2015-102054.
[27] F. Yaghmaie, "Archive of SID Content validity and its estimation Archive of SID," *Journal of Medical Education*, vol. 3, no. 1, pp. 25–27, 2003.
[28] D. A. Cook and T. J. Beckman, "Current concepts in validity and reliability for psychometric instruments: Theory and application," *American Journal of Medicine*, vol. 119, no. 2, pp. 166.e7-166.e16, Feb. 2006, doi: 10.1016/j.amjmed.2005.10.036.
[29] L. Sürücü and A. Maslakçı, "Validity and reliability in quantitative research," *Business & Management Studies: An International Journal*, vol. 8, no. 3, pp. 2694–2726, 2020.
[30] M. Mansoor, T. M. M. Awan, and B. Alobidyeen, "Structure and measurement of customer experience management," *International Journal of Business and Administrative Studies*, vol. 6, no. 4, Aug. 2020, doi: 10.20469/ijbas.6.10001-4.
[31] R. Heale and A. Twycross, "Validity and reliability in quantitative studies," *Evidence-Based Nursing*, vol. 18, no. 3, pp. 66–67, May 2015, doi: 10.1136/eb-2015-102129.
[32] H. K. Mohajan, "Two Criteria for Good Measurements in Research: Validity and Reliability," *Annals of Spiru Haret University. Economic Series*, vol. 17, no. 4, pp. 59–82, Dec. 2017, doi: 10.26458/1746.
[33] T. S. Hancock, P. J. Friedrichsen, A. T. Kinslow, and T. D. Sadler, "Selecting Socio-scientific Issues for Teaching: A Grounded Theory Study of How Science Teachers Collaboratively Design SSI-Based Curricula," *Science and Education*, vol. 28, no. 6–7, pp. 639–667, Jul. 2019, doi: 10.1007/s11191-019-00065-x.
[34] M. Z. Bin Mustafa, M. N. Bin Nordin, and A. R. Bin Abdul Razzaq, "Structural equation modelling using AMOS: Confirmatory factor analysis for task load of special education integration program teachers," *Universal Journal of Educational Research*, vol. 8, no. 1, pp. 127–133, Jan. 2020, doi: 10.13189/ujer.2020.080115.
[35] M. Maidiana, "Survey research," (in Indonesian), *ALACRITY: Journal of Education*, vol. 1, no. 2, pp. 20–29, Jul. 2021, doi: 10.52121/alacrity.v1i2.23.

[36] J. L. Arbuckle, "IBM SPSS Amos 23 User's Guide." Amos Development Corporation, 2014. [Online]. Available: http://www.csun.edu/itr/downloads/docs/IBM_SPSS_Amos_User_GuideV23.pdf
[37] J. Choi, W. Fan, and G. R. Hancock, "A note on confidence intervals for two-group latent mean effect size measures," *Multivariate Behavioral Research*, vol. 44, no. 3, pp. 396–406, Jun. 2009, doi: 10.1080/00273170902938902.
[38] M. R. Kalafatoğlu, N. Ç. Kasik, Y. Barut, and O. Akkaya, "Adaptation of workplace dignity scale to Turkish: Validity and reliability studies," *Turkish Psychological Counseling and Guidance Journal*, vol. 11, no. 61, pp. 281–295, 2021.
[39] J. F. Hair Jr, W. C. Black, B. J. Babin, R. E. Anderson, and R. L. Tatham, *Multivariate data analysis*. Upper Saddle River, New Jersey: Pearson Education International, Inc, 2006.
[40] T. Safaria, "The Role of Leadership Practices on Job Stress among Malay Academic Staff: a Structural Equation Modeling Analysis," *International Education Studies*, vol. 4, no. 1, Jan. 2011, doi: 10.5539/ies.v4n1p90.
[41] W. Minto, *Easy, fast, precise use of Amos tools in applications (SEM)*. UPN Veteran Jatim (in Indonesian), 2016.
[42] A. Ferdinand, *Structural equation modeling in management research*. Semarang: FE UNDIP (in Indonesian), 2002.
[43] S. Nam, D. Kim, and C. Jin, "A Comparison Analysis among Structural Equation Modeling (AMOS, LISREL and PLS) Using the Same Data," *Journal of the Korea Institute of Information and Communication Engineering*, vol. 22, no. 7, pp. 978–984, 2018.
[44] L. D. Bacon and L. D. Bacon, *Using Amos for structural equation modeling in market research*. Lynd Bacon & Associates Limited and SPSS Incorporated Chicago, IL, 2001.
[45] T. Soseco, "Encouraging the rural education sector," (in Indonesian), *Jurnal Ekonomi dan Studi Pembangunan*, vol. 7, no. 2, pp. 1–8, 2015.
[46] N. Shofiyah and N. A. Faizah, "Science literacy profile of students in urban and rural public junior high schools," (in Indonesian), *SEJ (Science Education Journal)*, vol. 2, no. 1, pp. 25–35, May 2018, doi: 10.21070/sej.v2i1.2157.
[47] L. Qodriyah, A. Anekawati, and L. F. Azizah, "Analysis of science literature capabilities of junior high school students based on city and village area in Sumenep regency," (in Indonesian), *Prosiding SNAPP*, 2021, pp. 8–15.
[48] M. Leasa, M. Talakua, and J. R. Batlolona, "The development of a thematic module based on Numbered Heads Together (NHT) cooperative learning model for elementary students in Ambon, Moluccas-Indonesia," *New Educational Review*, vol. 46, no. 4, pp. 174–185, Dec. 2016, doi: 10.15804/tner.2016.46.4.15.

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