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Instrumental Analysis of Student Perceptions of Chemistry Learning with the STEM Approach at the end of the Covid-19 Pandemic using Second Order Confirmatory Factor Analysis

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Abstract: This study aims to prove the construct validity and reliability of students' perceptions of chemistry learning instruments using the STEM approach using Second Order Confirmatory Factor Analysis. The sample in this study was 455 public high school students spread across South Bengkulu district, Bengkulu Province. The instrument developed is a questionnaire instrument using a Likert scale which consists of four dimensions, namely the scientific dimension (DS), the mathematical dimension (DM), the engineering and technology dimension (DTT) and the STEM dimension (DST). The results of the study show that the four dimensions have good validity and are still acceptable because the loading factor value is above 0.40. In proving reliability using Cronbach's Alpha, a value of > 0.6 (0.855) was obtained so that it was declared reliable and in further analysis proving construct reliability using Composite Reliability (CR) showed that all dimensions of student perceptions had good construct reliability as well.

Keywords: Confirmatory Factor Analysis; Student Perception; Chemistry learning; STEM approach

Introduction

The Covid-19 pandemic until early 2022 made chemistry teachers and lab assistants as well as students study remotely, distance learning chemistry brought diverse perceptions, especially high school students. According to Accettone (2021) alternatives to remote laboratory learning in the form of video recording experiments and online simulations are seen as less effective for the overall student learning experience. Students need direct experience and practice so that there are no different perceptions from the teacher when teaching. in the use of web technology, students' perceptions in learning chemistry are described by Iyamuremye et al. (2022) that students and teachers have expressed positive perceptions of the application of web-based chemistry lesson discussions in the teaching and learning process, therefore, teachers and students are advised to access universal chemistry networks and conduct web-based discussions to improve student performance.

Students' perceptions of chemistry learning are a form of response or feedback after students receive a series of chemistry learning activities, both theoretically and practically. Meanwhile, from the teacher's point of view, Mindayula & Sutrisno (2021) argue that the teacher's perception is not familiar with the term multiple representation in chemistry. Then, the level of representation that is often applied by teachers in chemistry learning is symbolic and macroscopic representation. Meanwhile, submicroscopic representation is still difficult for teachers to apply in the chemistry learning process. Midak et al. (2021) explained that modern teachers and educational institutions have a big challenge to organize learning activities so that students are given the necessary skills and to meet their educational needs.

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Learning with a Science, Technology, Engineering, and Mathematics (STEM) approach is a necessity today. These four aspects are a proportional combination for problem-based learning. The STEM approach is considered capable of answering challenges to solve problems. Not only that, learning with the STEM approach according to Jawad & Majeed (2021) is able to provide instructional as well as information, plans and activities designed according to the STEM approach and can help math and science teachers later in facilitating the teaching of mathematics, science and scientific concepts and principles.

Fan et al. (2021), states that an effective STEM pursuit strategy depends on content integration, focusing on frameworks that are learning activities, such as investigations and experiments and designs to integrate STEM content into learning and help students develop their competencies. meanwhile Zizka et al. (2021) added that learning with STEM programs currently offers theoretical knowledge and industry-related competencies that seek to prepare STEM graduates to become leaders to meet the demands of the 21st century (Baran et al., 2016; Lestari et al., 2018; Nuraini, 2020; Uğraş, 2018; Wahono & Chang, 2019). So it is expected that graduates will produce agents of change with a more intrinsic perspective on sustainability than the perspective obtained gradually after entering their respective professions. For teachers the STEM approach also has benefits as stated by Lin et al. (2021) that STEM project-based learning is useful for developing teacher thinking schemes, especially those related to clarifying problems, generating ideas, modeling, and feasibility analysis and is important for encouraging teachers to further explore learning concepts.

Meanwhile the STEM approach in chemistry learning according to Aguilera & Ortiz-Revilla (2021) seeks to update the scientific literacy of the younger generation and with the inclusion of art, student creativity is described as a key skill that must receive special attention. Hardy et al. (2021) stated that chemistry lessons in higher education and the importance of the real world in personal, organizational, national, and global contexts can outline the development and implementation challenges associated with the old infrastructure of higher education, especially highlighting that chemistry as one of the disciplines that supports industry and is able to employ millions of people worldwide.

The perception instrument used in this study aims to determine students' perceptions of chemistry learning using the STEM approach, which is then tested for validity and reliability using Second Order Confirmatory Factor Analysis. Second Order CFA is a confirmatory factor analysis with two orders. This analysis is used to interpret the scale as multi-level as well as multidimensional by bringing the various dimensions under the factor rubric of a higher general level (Gould, 2015). CFA aims to test the suitability of a data with a hypothesized model. Thus, in this study Second Order CFA will be used to determine the instrument's ability to collect data on students' perceptions of chemistry learning using the STEM approach.

Method

In this study, confirmatory factor analysis (CFA) was used to prove the instrument validation of students' perceptions of learning chemistry using the STEM approach at public high schools in South Bengkulu Regency, totaling 11 high schools. Participants in this study were students majoring in Natural Sciences (IPA), with a total sample of 455 students. Sampling using Proportionate Stratified Random Sampling technique. The instrument used to measure student perceptions in this study used a closed questionnaire with a Likert scale that was constructed by the researchers themselves. The measurement scale used consists of five categories, namely strongly agree (SS), agree (S), neutral (N), disagree (TS), and strongly disagree (STS) (Azwar, 2019).

The dimensions and indicators of constructing students' perceptions of chemistry learning with the STEM approach can be seen in Table 1. The type of CFA used in this study is Second Order Confirmatory Factor Analysis. This type is used for measuring indicators that cannot be measured directly, but can be measured by several items used as observed variables (Hendryadi & Suryani, 2014). Testing the second order CFA can be done by looking at the loading factor value (> 0.5) and the calculated t value (> 1.96). A factor loading weight of 0.50 or more is considered to have sufficiently strong validity to explain latent constructs (Ghozali & Fuad, 2012; Hair et al., 2010). However, in development, factor loading values ≥ 0.4 are acceptable or have meaning (Retnawati, 2016).

Tabel 1. Dimensions and Indicators of Students' Perceptions

Dimensions	Indicator
Science	Interests, abilities, difficulties, readiness, benefits, influence and careers in science, especially chemistry
Matematika	Interests, abilities, difficulties, readiness, benefits, and career choices in mathematics
Engineering and Technology	Interests, abilities, difficulties, readiness, benefits, Learning to use technology, creating new products, and careers in engineering
STEM	Interest, ability, readiness, using creativity and innovation for future jobs and STEM careers.

A construct has good reliability if the value of Construct Reliability (CR) ≥ 0.70 (Ghozali & Fuad, 2012). The amount of reliability in this study uses the Formula 1:

Construct reliability/CR formula

$$CR = \frac{(\sum \lambda_i)^2}{(\sum \lambda_i)^2 + (\sum 1 - \lambda_i^2)} \tag{1}$$

Where CR = Composite Reliability, λi is the loading component to the indicator.

Besides that, reliability verification was also carried out using the Cronbach's Alpha formula to see the reliability of the instrument (Arikunto, 2013). The Cronbach's Alpha formula 2:

$$r_{11} = \left[\frac{\mathrm{k}}{\mathrm{k}-1}\right]\left[1 - \frac{\sum \sigma_b^2}{\sigma_t^2}\right] \tag{2}$$

Where r_{11} = instrument reliability, k = number of questions or questions, $\sum \sigma_b{}^2$ = number of item variances and $\sigma_t{}^2$ = total variance.

Result and Discussion

In this study, data analysis was performed using Second Order Confirmatory Factor Analysis using the Lisrel 8.8 program. The first part to pay attention to is the fit of the model. From the results of the analysis, it was found that the p-value = 0.00000 (<0.05) so that the model was not fit (Augusty, 2002). However, judging from the value of RMSEA = 0.075 (<0.08) it shows that the fit of the model is good (Augusty, 2002; Pham, 2020; Sarwono, 2010). Other model compatibility indices such as GFI, AGFI, NFI and RFI produce scores above 0.80 and also NNFI, CFI, IFI, and GFI produce scores above 0.90 (good fit models) (Augusty, 2002; Kerlinger & Pedhazur, 1973). This condition shows that the population covariance matrix has no difference with the sample data covariance matrix so that it can be used as a basis for making generalizations.

After obtaining the fit model, several other outputs are interpreted, one of which is the Standardized Solution as can be seen in Figure 1. Some experts say that this path coefficient is meaningful if the value is not less than 0.4 (Retnawati, 2016).

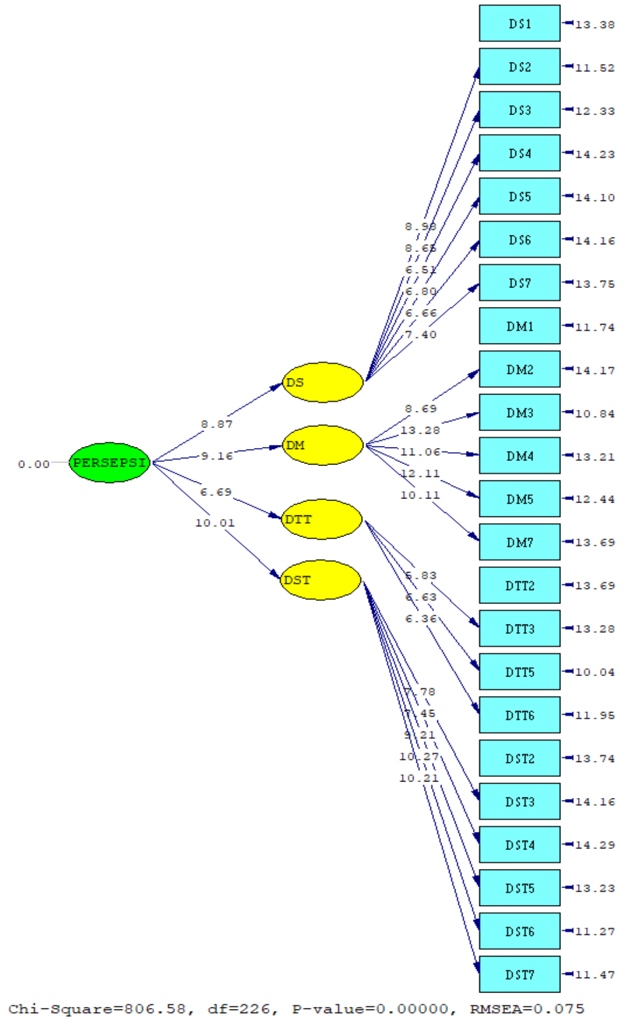

Figure 1. Output Standardized Solution

Based on Figure 1 it can be seen that all paths have a path coefficient of more than 0.4. This shows that all of these paths have meaning (meaningful). For further analysis, you can see the significant path or the significance of the meaningfulness of the relationship by looking at the T-value. The T-value for this model is presented in Figure 2.

Based on Figure 2, the results of the analysis show that all indicators have a t-value greater than 1.96 (except for 4 indicators whose t-value does not appear because they are placed as reference variables, namely DS1, DM1, DTT2 and DST2). This can be seen also from the absence of a red line. So the results of this analysis indicate that all observable variables make a significant contribution to measuring latent variables. Summary of analysis results for Standardized Solution and T-value can be seen in Table 2.

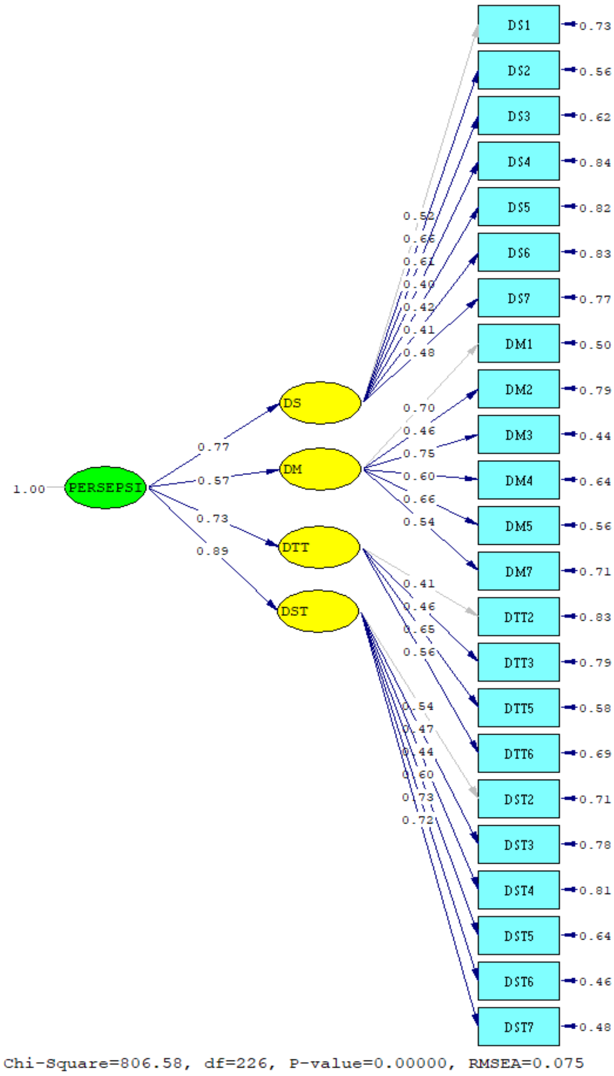

Figure 2. Output t-value

Furthermore, for the second level, an analysis is carried out from the latent construct to the dimensional construct. Based on the results of the analysis test, it showed that all loading factor values were > 0.5 and T-values were > 1.96. To more clearly see the summary of the analysis results in Table 3.

These results indicate that the four dimensions of students' perceptions of chemistry learning with the STEM approach which consist of the dimensions of science, mathematics, engineering and technology, and STEM are said to be valid and significant for measuring the latent variables of student perceptions.

Based on the reliability calculation formula using Cronbach's Alpha, a value of 0.855 is obtained or greater than the minimum limit of 0.6 (Arikunto, 2013; Ursachi et al., 2015). So it can be concluded that all indicators in the model are reliable. In addition, from the results of calculating the reliability construct, the CR results for each dimension of student perception can be seen in Table 4.

Table 2. Second Order CFA Analysis Results (Aspects of Indicators)

Item	Loading Factor	T-value	Conclusion
DS1	0.52		
DS2	0.66	8.98	Sig
DS3	0.61	8.65	Sig
DS4	0.40	6.51	Sig
DS5	0.42	6.80	Sig
DS6	0.41	6.66	Sig
DS7	0.48	7.40	Sig
DM1	0.70		
DM2	0.46	8.69	Sig
DM3	0.75	13.28	Sig
DM4	0.60	11.06	Sig
DM5	0.66	12.11	Sig
DM7	0.54	10.11	Sig
DTT2	0.41		
DTT3	0.46	5.83	Sig
DTT5	0.65	6.63	Sig
DTT6	0.56	6.36	Sig
DST2	0.54		
DST3	0.47	7.78	Sig
DST4	0.44	7.45	Sig
DST5	0.60	9.21	Sig
DST6	0.73	10.27	Sig
DST7	0.72	10.21	Sig

Table 3. Second Order CFA Analysis Results (Latent Aspect)

Dimensions	Loading Factor	T-value	Conclusion
Science (DS)	0.77	8.87	Sig
Mathematics (DM)	0.57	9.16	Sig
Engineering and Technology (DTT)	0.73	6.69	Sig
STEM (DST)	0.89	10.01	Sig

Table 4. Results of the analysis of the reliability construct calculation

Dimensions	CR
Science (DS)	0.70
Mathematics (DM)	0.79
Engineering and Technology (DTT)	0.60
STEM (DST)	0.76

Based on Table 4, the CR value for each dimension ≥ 0.60. According to Waluyo (2016) reliability between 0.5 – 0.6 is acceptable, so it can be concluded that indicators and items are reliable in explaining students' perception constructs.

Based on the results of the analysis of construct validity and construct reliability, all dimensions and items that form student perceptions are declared valid and reliable so that all dimensions and indicators are able to reflect and measure the level of students' perceptions of learning chemistry with the STEM approach. The most dominant dimension that reflects student perceptions is the STEM dimension and the dimension that least reflects student perceptions is the engineering and technology dimension.

In the analysis using Lisrel, deletion was carried out on several statement items, namely the DM6, DTT1, DTT4, and DST1 indicators. This is caused by the value of the loading factor which is less than 0.4.

Students' perceptions can influence their interests, attitudes and behavior towards the learning process in the classroom. So that students are expected to have a positive perception of learning so that the teaching and learning process will run well. If negative perceptions are raised by students, then it can make students avoid the learning process because it is considered too difficult (Haney et al., 2002; Patrick et al., 2021). Therefore, it is necessary to identify students' perceptions of learning that will be applied in class (Srikoom et al., 2017). Fitrianasari & Budiyanto (2015) in their research stated that perception is very important, especially in life, because it can influence a person's perspective, understanding, response, attitude and behavior in this case students towards perceived objects, namely learning chemistry with the STEM approach.

Conclusion

The conclusion that can be drawn based on the results of the analysis in this study is that the student perception instrument has good construct validity and reliability, so that this instrument can be used to measure the level of student perception of learning chemistry with the STEM approach. Suggestions for further research are to be able to develop other students' perception instruments on chemistry learning, so as to improve the quality of learning through teaching and learning processes that can run even better.

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