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Research Article

Self-efficacy assessment in chemistry learning: Development and validation using confirmatory factor analysis

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Abstract

Learner self-efficacy is the confidence of a learner to determine how he feels, thinks, motivates and behaves. The purpose of this study was to analyze the instrument of self-efficacy assessment of students in the Aliyah madrasah in Musi Rawas Prov. South Sumatra. The total of respondents to testing this instrument was 234 students. This study uses Second Order Confirmatory Factor Analysis (CFA) to determine the validity and reliability of Likert scale instruments regarding students' self-efficacy in chemistry learning. The sampling technique used is proportionate Stratified Random Sampling. The research results show that the instrument developed has good construct validity as seen from the loading factor value > 0.50. The construct reliability test using CR and AVE values also showed acceptable results so it was declared suitable for use in data collection to measure self-efficacy in learning chemistry. It is hoped that teachers can measure student self-efficacy using this instrument. It is expected that teachers can measure students' self-efficacy using this instrument.

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Introduction

The increase in Covid-19 cases in Indonesia prompted the government to implement online learning policies and close schools temporarily, with the main aim of stopping the spread of viruses that are harmful to human health (Naqsyahbandi and Prodjosantoso, 2023). However, the negative effects of school closures due to the Covid-19 pandemic on student learning have the potential to last for a long period of time (Di Pietro, 2023). Significant technological advances have resulted in widespread and rapid dissemination of information at all levels of society, but there has not been adequate suitability in its usability (Muhariyansah et al. 2021). The impact is that students face challenges in the learning process and achieve educational goals, where learning achievement is one of the indicators of educational success (Purwanto, 2014).

Learning attainment is influenced by a variety of factors, including internal factors such as physical and psychological health conditions, as well as external factors. One of the psychological factors that have an influence on learning achievement is self-efficacy (Kurbanoglu and Takunyaci, 2012; Hyang and Sook, 2015; Istiqfar et al. 2018) Although self-efficacy is a concept that originated and developed within the field of psychology, its importance and relevance have expanded factually beyond the boundaries of the discipline to encompass a wide range of related disciplines, including the world of Education (Bouih et al. 2021).

Learners who have a high level of self-efficacy show greater confidence in the learning process, are able to cope with problems more effectively, and are more involved in learning activities. On the other hand, students who have low levels of self-efficacy tend to avoid challenges, which ultimately negatively impacts their academic performance (Meng and Zhang, 2023). Learners' self-efficacy refers to learners' beliefs in regulating their feelings, thoughts, motivations, and behaviors (Bandura, 1994). Furthermore, learners have confidence in their

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ability to improve achievement after being given tasks and experiences that affect their lives. Meanwhile, learners who have a high level of self-efficacy will show greater effort in facing challenges.

In the context of education, if learners have a high level of self-efficacy, they will be motivated to achieve learning goals and persist when facing difficulties, including in completing tasks, besides self-efficacy has a positive and significant influence on achievement (Karadağ, 2017). Therefore, self-efficacy has a significant impact on learning outcomes (Cikrikci, 2017; Erdem, 2015; Gao et al. 2021; Hartati et al. 2021). Significance in the development of instruments to measure self-efficacy can be seen through its ability to identify factors that influence an individual's level of self-efficacy (Zimmerman, 1995). Through measuring self-efficacy and its relationship to other variables such as experience, family support, or teaching strategies, we can gain a deeper understanding of the factors that contribute to an individual's level of self-efficacy. This information can then be used to design appropriate interventions or strategies to improve an individual's self-efficacy.

Method

Population and Sample

The respondents for testing this instrument were students of classes X, XI and XII of Science at Madrasah Aliyah in Musi Rawas Regency with a total sample of 234 students.

General Procedure

This study uses Second Order Confirmatory Factor Analysis (CFA) to determine the validity and reliability of Likert scale instruments regarding students' self-efficacy in chemistry learning. The sampling technique used is proportionate Stratified Random Sampling. The Likert scale developed uses five categories, namely Strongly Agree (SS), Agree (S), Simply (C), Disagree (TS), and Strongly Disagree (STS) (Azwar, 2019). The application of Confirmatory Factor Analysis (CFA) is used in research when the researcher has an understanding of the structure of the latent variable on which it is based. In CFA, latent variables will be correlated in a structured manner to reveal the existence or absence of relationships between these variables. The correlation between two latent variables can produce good or bad results, depending on the relationship expected in a model (Beckett et al. 2018).

The instrument was developed based on a synthesis of several expert opinions which was then used as a new instrument to measure the self-efficacy of Madrasah Aliyah students in Musi Rawas District, this is explained in Table 1:

Table 1. Dimensional synthesis on self-efficacy assessment in chemistry learning

Uzuntiryaki and Aydin (2009)	Suprapto et al. (2017)	Bandura (1994)	Instrument synthesis based on references
1. Self-efficacy for knowledge	1. Science content	1. Mastery experience	1. Mastery experience
2. Self-efficacy for higher-order skills	2. Higher-order thinking	2. Vicarious experience	2. Higher-order thinking
3. Self-efficacy for psychomotor skills	3. Laboratory usage	3. Verbal persuasion	3. Science communication
4. Self-efficacy for everyday applications	4. Scientific literacy	4. Psychological and affective state	4. Daily science applications
	5. Everyday science Application		
	6. Science communication		

Data Analysis

Assisted data processing with SPSS and AMOS 22 software. The dimensions of self-efficacy are Mastery Experience (PP), Higher Order Thinking (BTT), Science Communication (KK) and daily Science Applications (AK) where each dimension is measured using 3 positive questions and 2 negative questions. The model fit indicator in Confirmatory Factor Analysis (CFA) has the following criteria: Chi-square/degree of freedom is accepted if the value is in the range of $2 \leq$ Chi-square/df ≤ 5, and a value of ≥ 5 is considered a good match. For Probability, it is accepted if the value is in the range of $0.01 \leq$ p-value ≤ 0.05, and a value of 0.05 is considered a good match. RMSEA (Root Mean Square Error of Approximation) ≤ 0.05 is considered a good match, $0.05 \leq$ RMSEA ≤ 0.08 is considered an adequate match, $0.08 \leq$ RMSEA ≤ 0.10 is considered a sufficient match, and RMSEA > 0.10 is considered a poor match. In addition, TLI (Tucker-Lewis Index), GFI (Goodness of Fit Index),

CFI (Comparative Fit Index), and IFI (Incremental Fit Index) values of ≥ 0.95 are considered a good match, ≥ 0.90 are considered an acceptable match, and a range of values of 0.8 ≤ x ≤ 0.9 is considered a marginal match (Herwin and Nurhayati, 2021).

Results and Discussion

The self-efficacy assessment instrument developed in this study has four dimensions, which are then evaluated against the level of data match through the overall model fit test and measurement model fit in the form of validity and reliability (Wijanto, 2008). There are 11 indicators that are eliminated to get the fit model, namely PP3, PP4, PP5, BTT3, BTT4, BTT5, KK4, KK5, AK3, AK4, and AK5. The results of the fit second-order confirmatory factor analysis model can be seen in Fig.-1.

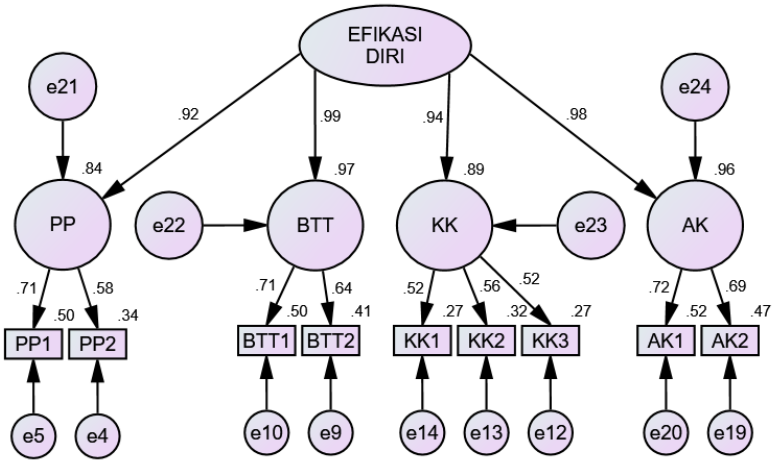

Fig.-1. Results of the second-order model fit confirmatory factor analysis

In the overall fit model, the final model results have a good match value. There are five parameters that meet the criteria for good fit, namely Chi-square/degree of freedom <5 (Pham et al. 2020), GFI, CFI, TLI, and IFI ≥ 0.9 (Bentler, 1990; Hair et al. 1998; Kline, 2005). The rest of the parameters meet the acceptable fit criteria (Ghozali, 2018; Pham et al. 2020). More complete results for the Goodness of Fit parameter can be seen in Table 2. The following items are presented indicators of the self-efficacy assessment instrument of students in Table 3.

Table 2. Complete results of goodness of fit parameters in the overall fit model test

	Measurement Results	Conclusion
Chi-square/ degree of freedom	2.117	Good fit
Probability	0.001	Acceptable fit
RMSEA	0.069	Acceptable fit
GFI	0.958	Good fit
CFI	0.955	Good fit
TLI	0.930	Good fit
IFI	0.956	Good fit
PRATIO	0.639	Acceptable fit
PNFI	0.588	Acceptable fit
PCFI	0.610	Acceptable fit

In the measurement model fit, the final result of construct validity is better after the elimination of item items. Item items are said to be valid in the CFA second order test if they have a loading factor value of > 0.5 (Hair et al. 2010; Naqshabandi et al. 2023). According to Ghozali and Fuad (2012), a loading factor value of 0.5 or more is considered to have strong enough validity to explain latent construction. More clearly the value of construct validity can be seen in Table 4.

Table 3. Items of student self-efficacy assessment instrument

Items	Information
PP1	I can explain the chemical concepts I know to my friends
PP2	Every day I study chemistry
PP3	My chemistry test scores always get good results
PP4	Although I have studied, but I still don't understand the subject of chemistry
PP5	I didn't master any chemistry
BTT1	When I encounter a chemical problem, I will strategize to solve the problem
BTT2	I can make systematic observations on chemical concepts
BTT3	I am able to propose many good solutions to solve chemical problems
BTT4	I was unable to design a chemistry lab to verify the hypotheses I had made
BTT5	When I explore chemistry issues, I can't afford to think of why.
KK1	I discuss with friends if there are chemicals that I don't understand
KK2	I am skilled in presenting the results of chemical experiments.
KK3	When the chemistry subject progresses, I can express my ideas well
KK4	I was unable to give an opinion on a presentation made by my friend relating to chemistry
KK5	I am not at ease to discuss chemistry content with classmates
AK1	I was able to explain chemical concepts related to everyday life
AK2	I can solve problems by using chemical concepts
AK3	I can interpret the social issues of chemistry related to chemistry
AK4	I don't care about phenomena in people's lives related to the concept of chemistry
AK5	I cannot use the scientific method to solve chemical problems in everyday life

Table 4. Results of the CFA second order test construct validity analysis

Items	Loading Factor			
	Beginning	Interpretation	End	Interpretation
PP5	0.496	Invalid		
PP4	0.489	Invalid		
PP3	0.474	Invalid		
PP2	0.438	Invalid	0.585	Valid
PP1	0.634	Valid	0.707	Valid
BTT5	0.486	Invalid		
BTT4	0.386	Invalid		
BTT3	0.438	Invalid		
BTT2	0.58	Valid	0.644	Valid
BTT1	0.642	Valid	0.709	Valid
KK5	0.52	Valid		
KK4	0.377	Invalid		
KK3	0.483	Invalid	0.517	Valid
KK2	0.492	Invalid	0.564	Valid
KK1	0.563	Valid	0.521	Valid
AK5	0.391	Invalid		
AK4	0.394	Invalid		
AK3	0.207	Invalid		
AK2	0.587	Valid	0.685	Valid
AK1	0.666	Valid	0.718	Valid

Next, in the construct reliability analysis in the CFA second order test, the CR and AVE values of the four dimensions changed better after the item elimination process. There are three of the four dimensions, namely PP, BTT, and AK dimensions that meet the minimum values for CR (>0.6) and AVE (0.4) (Fornell and Larcker, 1981; Lam, 2012). While the KK dimension has a CR value of 0.5 and AVE of 0.3 so it is not accepted, but it is still calculated for use with consideration of a fairly strong theoretical foundation. Therefore, these results

indicate that all dimensions of the self-efficacy assessment instrument in chemistry learning are considered reliable and can be used to measure appropriate data. The results of CR and AVE values in each dimension for self-efficacy can be seen in Table 5.

Table 5. Analysis results reliability of CFA second order test

Dimensions	Composite Reliability (CR)			Average Variance Extracted (AVE)		
	Beginning	End	Interpretation	Beginning	End	Interpretation
PP (Mastery Experience)	0.6	0.9	Acceptable	0.3	0.4	Acceptable
BTT (Higher order thinking)	0.6	0.9	Acceptable	0.3	0.5	Acceptable
KK (Science Communication)	0.6	0.5	Not acceptable	0.2	0.3	Not acceptable
AK (Daily Science Applications)	0.6	0.7	Acceptable	0.2	0.5	Acceptable

Based on the findings of the second order analysis of CFA, the four dimensions in this study are significant to the instrument of self-efficacy in chemistry learning. This is indicated by the loading factor values on the final fit model, all of which are at or above 0.5. The dimension that contributed the least to the self-efficacy variable was the Mastery Experience (PP) dimension with a loading factor value of 0.92. While the dimension that contributes the most with a loading factor value of 0.99 in the Higher Order Thinking (BTT) dimension.

Referring to the results of the measurement model fit analysis, shown in Table 4 and Table 5, the self-efficacy assessment instrument in chemistry learning developed in this study produces construct validity values and construct reliability above the minimum limit set by experts so that it can be concluded that the instrument is reliable and feasible to use.

Conclusion

Based on the results and discussion, four dimensions have been determined, namely Mastery of Experience (PP), Higher Order Thinking (BTT), Communication Science (KK) and Daily Application of Science (AK). There were 11 indicators that were removed to obtain a fit model using second-order CFA. The results show that the self-efficacy assessment instrument in chemistry learning is proven to have good construct validity as seen from the loading factor value > 0.50. In the construct reliability test using CR and AVE values also showed acceptable results. Therefore, the instrument developed was declared suitable for use in collecting data to measure self-ability in chemistry learning. It is hoped that teachers can measure student self-efficacy using this instrument. So that teachers can provide appropriate evaluations of their students' abilities or competencies in carrying out a task, achieving goals, or overcoming obstacles in the learning process.

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

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