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Scientific Attitude of Prospective Science Teachers in Indonesia: A Psychometric Evaluation

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Abstract: The purpose of this study was to evaluate the scientific attitude of prospective science teacher students as well as to validate the scientific attitude assessment instrument that had been developed (Moore & Foy, 1997). This research procedure includes adapting the instrument, analyzing the content validity, delivering the instrument to sample and evaluating the research data. The data obtained were analyzed statistically using factor analysis techniques to determine the contribution of each item, analysis the reliablity and Pearson product moment correlation. The research sample was 525 prospective science teachers who were taken by using random technique at University of Lampung. The results showed that scientific attitude consisted of 4 main factors, namely science is about understanding, explaining, and aiming to help other people's lives better (factor 1), I want to become a scientist (factor 2), the task of a scientist (factor 3), and science is rigid (factor 4). Furthermore, factor 3 and factor 1 as the dominant scientific attitude possessed by students, followed by factor 2 and factor 4. The scientific attitude was dominated by the understanding that science is about understanding and explaining scientific facts and the obligations of a scientist. . But they themselves do not really want to be a scientist. The structural model was declared valid, and according to the model fit index criteria, $\chi2$ / df, GFI, AGFI, RMR, RMSEA, CFI, NFI, dan IFI with successive values of 1.331/($p < 0.05$); 0.981; 0.968; 0.022; 0.025; 0.91, 0.988; 0.954; 0.937.

Keywords: scientific attitude, academic achievement, factor analysis

Abstrak: *Tujuan penelitian ini adalah untuk mengevaluasi sikap ilmiah siswa calon guru IPA serta untuk memvalidasi instrumen penilaian sikap ilmiah yang telah dikembangkan (Moore & Foy, 1997). Prosedur penelitian ini meliputi mengadaptasi instrumen, menganalisis validitas isi, mendistribusikan instrumen ke sampel dan mengevaluasi data penelitian. Data yang diperoleh dianalisis secara statistik menggunakan teknik analisis faktor untuk mengetahui kontribusi masing-masing item, analisis reliabilitas dan korelasi product moment Pearson. Sampel penelitian ini adalah 525 calon guru IPA yang diambil dengan teknik random di Universitas Lampung. Hasil penelitian menunjukkan bahwa sikap ilmiah yang terdiri dari 4 faktor utama yaitu sains adalah tentang memahami, menjelaskan, dan bertujuan untuk membantu kehidupan orang lain lebih baik (faktor 1), saya ingin menjadi ilmuwan (faktor 2), tugas seorang ilmuwan (faktor 3), dan sains bersifat kaku (faktor 4). Selanjutnya faktor 3 dan faktor 1 sebagai sikap ilmiah dominan yang dimiliki siswa, disusul faktor 2 dan faktor 4. Sikap ilmiah didominasi oleh pemahaman bahwa sains adalah tentang memahami dan menjelaskan fakta ilmiah dan kewajiban seorang ilmuwan. . Tapi mereka sendiri tidak terlalu ingin menjadi ilmuwan. Model struktural dinyatakan valid, dan sesuai dengan kriteria model fit index,* $\chi2$ / df, *GFI, AGFI, RMR, RMSEA, CFI, NFI, dan IFI dengan nilai berturut-turut sebesar 1,331/(p < 0,05); 0,981; 0,968; 0,022; 0,025; 0,91, 0,988; 0,954; 0.937.*

Kata kunci: *sikap ilmiah, prestasi akademik, analisis faktor.*

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▪ INTRODUCTION

Scientific progress depends on continuous scientific research. Science teaching is strongly influenced by an education system that is well organized and equipped with good laboratories. It has also been shown that one of the most important factors in teaching science is attitude that determines behavior (Amjad & Muhammad, 2012). One of the goals of science education is to encourage students to have a positive attitude towards science in order to have a positive effect on student learning (Northwest Region Education Laboratory (NREL), 2002). According to Karlinger (1970), attitudes are psychological constructs, or latent variables, inferred responses to stimuli from observables that are thought to mediate the consistency and coherence among these responses. Attitudes relate to thinking, feeling, understanding, and behaving towards cognitive objects.

Scientific attitude is the most important outcome of teaching science. Science teachers should make special efforts to increase the scientific attitude of their students. Open mind, curiosity, judgment based on verified facts, readiness to be tested and verify conclusions, faith in cause and effect relationships, willingness to reconsider judgments, freedom from superstitions and false beliefs, honesty in recording, collecting, and reporting scientific data, critical in observation, and more trust in books written by specialists in their respective fields are some of the characteristics of a scientific attitude. Scientific attitude is curiosity to know about one's environment; the belief that nothing can happen without a cause and events that seem strange and mysterious can always be explained by natural causes (Caldwell & Curits, 1943).

Certain societal ethics and values, such as honesty, reason, objectivity, and making decisions based on accurate information, can be instilled in our young through science. A person's behavior and actions reflect a person's scientific attitude, which is a synthesis of numerous qualities and virtues. These people are open-minded, experiment-oriented, systematic in approach, have a love for knowledge, are intellectually honest, unbiased, honest, and have a science temper and hope that problem solutions will come through the use of verified knowledge (Jancirani, Dhevakrishnan & Devi , 2012).

The academic performance of the students themselves and their ability to apply scientific methods in acquiring knowledge is largely determined by the scientific attitude of the students themselves (Ebenuwa-Okoh, 2010; Turiman et al., 2012; Park et al., 2005). Moore & Foy (1997) divided scientific attitudes into 12 factors while Lichtenstein et al. (2008) made the antithesis of this research by stating that scientific attitude only has 3 factors. A teacher's and lecturer's knowledge of a student's or student's scientific attitude becomes extremely crucial in order to maximize a student's academic success. Therefore, in this study a psychometric analysis was carried out on the scientific attitude of the Unila MIPA Education Department students. In order to increase the quality of students in the Mathematics and Science Education Department at the University of Lampung, knowledge of the student's scientific attitude will be a suggestion.

▪ METHOD

This study relied on a survey of Mathematics and Natural Sciences Education (PMIPA) students at the University of Lampung's Faculty of Teacher Training and Education. The sample of research was 525 prospective science teachers who were taken by using random technique at University of Lampung. The sample was prospective science teacher in the odd semester of 2018/2019 academic year which consists of students in semester 1, 3, 5.

This study was carried out in multiple stages, the first of which was the adaptation of the instrument based on a review of the literature on the student's scientific attitude instrument. Then, after validating the content's validity, distribute the instrument to the research sample. The next step is to study the research data on each element that influences students' scientific attitudes and its relationship to academic accomplishment. Moore and Foy designed a scientific attitude scale questionnaire for MIPA prospective students, which was employed in this study (1997). The instrument will contain 40 question items that will be translated and transliterated into Indonesian, making each item in the instrument easier to grasp for study subjects. The data collection method used in this study is a traditional survey method, in which students who are prospective teachers of sciences were given a questionnaire instrument based on a scientific attitude scale.

In this study, data was analyzed in multiple steps, including combining student responses in each instrument item and coding according to the five levels of the Likert scale; determining the construct validity of the instrument utilized; and analyzing the validity of the instrument. Items that are retained in the instrument must have a loading factor of greater than 0.40, according to Stevens (2002)'s validation criteria, and items with a loading value of less than 0.40 will be automatically excluded in the analysis of each item in the instrument. n this work, the principle of extracting principal components with orthogonal rotation is utilized to determine the number of possible elements and contribute to construct validity in the constructed student attitude instrument toward mathematics. Then, using Cronbach's alpha coefficient, assess the reliability of each dimension in the instrument of student attitudes toward mathematics. To describe the level of student understanding of mathematics, the average value and standard deviation for each dimension in mathematical attitudes are calculated (according to their respective perceptions). Using Pearson's product moment, examine the relationship between each item and each dimension of scientific attitude. Using chi-square, RMSEA, CFI, and CI, we tested the constructs produced in the EFA analysis based on the model's appropriateness criteria. Finally, examine the impact of gender, academic level, and their interplay on potential science teachers' scientific attitudes.

▪ RESULT AND DISCUSSION

This study was aimed at evaluating the scientific attitude of MIPA education students, FKIP Unila as prospective MIPA teachers as well as validating the scientific attitude assessment instrument that had been developed (Moore & Foy, 1997). An exploratory factor analysis procedure with orthogonal varimax rotation method was applied to clarify the structural factors formed from a number of items in the instrument. Prior to further EFA analysis, the Kayser-Mayer-Olkin test and Bartlett spesicity test were first performed. The test is used to test whether the resulting data set is suitable for analysis using EFA. KMO and Bartlett test values can be observed in Table 1 below.

Table 1. KMO test value and Bartlett specificity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,886
Bartlett's Test of Sphericity	Approx. Chi-Square	6220,639
	df	780
	Sig.	0,000

Based on table 1, it is known that the KMO sampling adequacy test value is 0.886 and the Bartlett test X2 = 6220.639 with a significance of 0.000 which indicates that the resulting data is very suitable for EFA analysis or in other words EFA analysis will provide accurate results relative to the data used. After determining that the data is eligible for EFA analysis, the varimax rotation results show that all items have an extraction value greater than 0.40, indicating that all items in the instrument do not need to be removed because they are believed to have contributed to each structural factor (latent factor).

Table 2. Extraction values from orthogonal rotations in EFA

Communalities

	Initial	Extraction
v1	1,000	,579
v2	1,000	,540
v3	1,000	,503
v4	1,000	,406
v5	1,000	,446
v6	1,000	,511
v7	1,000	,582
v8	1,000	,701
v9	1,000	,459
v10	1,000	,511
v11	1,000	,494
v12	1,000	,651
v13	1,000	,557
v14	1,000	,587
v15	1,000	,575
v16	1,000	,576
v17	1,000	,581
v18	1,000	,552
v19	1,000	,608
v20	1,000	,651
v21	1,000	,628
v22	1,000	,584
v23	1,000	,576
v24	1,000	,640
v25	1,000	,533
v26	1,000	,519
v27	1,000	,555
v28	1,000	,568
v29	1,000	,600
v30	1,000	,519
v31	1,000	,571
v32	1,000	,663
v33	1,000	,628
v34	1,000	,478
v35	1,000	,624
v36	1,000	,628
v37	1,000	,422
v38	1,000	,500
v39	1,000	,496
v40	1,000	,568

Furthermore, the EFA analysis revealed that the instrument's items were divided into ten factors. However, some sources propose discarding or rejecting all components with less than three entries. As a result, factor numbers 6, 9, and 10 will be removed from further investigation with confirmatory factor analysis in this scenario.

Table 3. Coefficient of rotated factor loadings, Cronbach's alpha, and variance

	Component (total Cronbach alpha = 0,82)									
	F1 (9,28%)	F2 (8,69%)	F3 (7,97%)	F4 (5,77%)	F5 (4,95%)	F6 (4,36%)	F7 (3,88%)	F8 (3,88%)	F9 (3,77%)	F10 (3,36%)
v29	,747									
v23	,657									
v31	,590									
v28	,542									
v2	,503									
v15	,457				,414					
v9	,427									
v30	,408									
v14		-,723								
v22		-,704								
v36		,661								
v13		-,645								
v27		,484								
v37		-,481								
v1		,479								
v33			,670							
v25			,644							
v39			,616							
v40			,582							
v17			,555							
v6				,659						

v7				,645						
v5				,628						
v38		-,425		,511						
v11				,456						
v16					,657					
v18					,604					
v4					,432					
v19						,740				
v10						,616				
v26							,641			
v24	,443						,598			
v35							,510			
v20								,616		
v3								-,592		
v21								,575		
v8									,751	
v12									-,735	
v32										,803
v34										,425

Furthermore, the EFA analysis reveals that the instrument's items are divided into seven categories with a total variance of 55.93% with details of the variance per factor as shown in table 4.3. This shows that the factors resulting from the EFA analysis are able to explain about 56% of all items. This percentage is the best that can be obtained in this study after trying various rotational and extraction methods, although the percentage is not that high. Therefore, these results need to be strengthened by other analyzes such as the CFA analysis so that the structural factors obtained are truly valid and can be trusted. The eigenvalues for the 7 factors obtained from the principal component analysis are more than 1, and the total variance (total variance explained) is 55.93% where the largest variance is owned by factor 1 with a percent variance of 9.28%. This indicates that factor 1 (as well as other factors) can explain more about the scientific attitude of MIPA education students. Table 4.3 also shows that the rotated factor loadings of each item in the question range from 0.408 to 0.803 which can be declared valid according to Stevens (2002) criteria.

In accordance with the validation criteria in the EFA analysis by Stevens (2002), items that are retained in the instrument must have a loading factor of more than 0.40 so that items with a loading factor of less than 0.40 will automatically be omitted in the analysis of each item in the instrument. The principle of principal component extraction with orthogonal rotation is used in this study to estimate the number of possible factors, as well as to contribute to construct validity in the developed scientific attitude instrument. Furthermore, the reliability of each factor may be evaluated based on the Cronbach's alpha coefficient value of 0.82 for all factors, indicating that the factors in the instrument have a good level of internal consistency to assess potential science teacher students' scientific attitudes.

Based on the structural recommendations in the previous exploratory analysis, the items grouped into 10 factors will then be analyzed through a series of CFA analysis procedures. Each factor is connected by one-way arrows to describe the relationship between endogenous factors and exogenous factors, while each latent factor is then connected by two-way arrows that illustrate the relationship between covanriances between latent factors. However, the CFA analysis could not be carried out because a series of CFA settings with SPSS-AMOS could not consider factors that only had 1-2 items. Only factors that are considered to have more than or equal to 3 items and factors with 1 or 2 items are omitted from the CFA analysis. This is because factors that only have less than 3 items are considered to be very weak or unstable; On the other hand, a factor consisting of 5 or more items with a loading value (0.50 or more) is preferred and indicates a solid factor (Osborne, J. W., & Costello, A. B., 2009). If the items are highly correlated (e.g., r >.70) and largely uncorrelated with other variables, a factor with only two items can be maintained (Yong, A. G., & Pearce, S., 2013). Researchers should defend a factor only if they are able to interpret it in meaningful ways, no matter how strong the evidence is to defend it based on empirical criteria (Worthington, R. L., & Whittaker, T. A., 2006). Therefore in this case the factors number 6, 9, and 10 will be omitted and will not be used for further analysis.

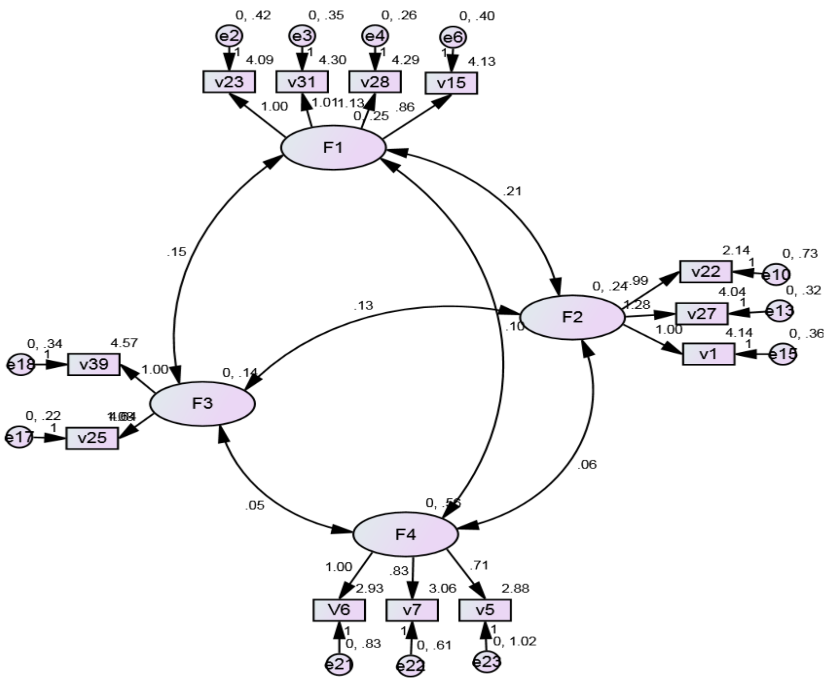

Figure 1. Structural model of scientific attitude of student teacher candidates for Mathematics and Natural Sciences

After following the suggestion of fitting the structural model according to the modification indices criteria to minimize errors in the structure, only 4 factors were obtained that were able to be maintained in the model as shown in Figure 4.1. Consider this based on the acceptable index as recommended by Joreskog & Sorbom (1993); Schermeleh-Engel, Moosbrugger, & Müller (2003); Kline (2005); and Sarsar & Kisla (2016) as shown in Table 4.

Table 4. Statistical value as an indicator of model fitting

	Acceptable Fit Index	Good Fit Index
X^2/df		<3
RMSEA	.05<RMSEA<.10	<.05
S-RMR	.05<S-RMR<.10	<.05
GFI	.90<GFI<.95	>.95
AGFI	.85<AGFI<.90	>.90
CFI	.90<CFI<.95	>.95

RMSEA : Root Mean Square Error of Approximation
GFI : Goodness of Fit Index
AGFI : Adjusted Goodness of Fit Index
S-RMR : Standardized RMR
CFI : Comparative Fit Index

The summary of the fit model obtained in this study are CMIN/DF = 1.331, GFI = 0.981, CFI = 0.988, RMSEA = 0.025. Analysis of the characteristics and degrees of student scientific attitude can be viewed from the mean of each latent factor and its comparison with the grandmean value. The dominating scientific attitude preference of prospective students of Mathematics and Natural Sciences teachers, particularly students of Mathematics and Natural Sciences University of Lampung, is a mean factor value bigger than the grandmean.

Table 5. The mean and standard error of each latent factor in scientific attitudes

Faktor	**Mean**	**SE**	**Rank***
1	4,20	0,025	2
2	3,48	0,018	3
3	4,60	0,023	1
4	2,95	0,035	4
GrandMean	3,80	0,017	

*Indicator: Mean > GrandMean

The Structural Equation Model is a statistical technique used in this investigation (SEM). The ability of SEM to ascribe correlations between latent variables (unobservable constructs) of observable variables is frequently supported in education. Ferdinand (2002) mentions that SEM is used to: (1) confirm the dimensions of various indicators for the dimensions, (2) check the compatibility of the model as either a causal relationship between the factors observed or constructed in the model, and (3) check the compatibility or accuracy of the model based on observed empirical data. A complete model is made up of two parts: a measurement model and a structural model. The measurement model's goal is to affirm the dimensions or factors based on empirical indicators, but the structural model's goal is to explain causality between factors by modeling the structure of the relationship. Absolute fit indices, incremental fit indices, and parsimony fit indices are the three types of goodness of fit (GIF) measures. However, depending on the intended objective, none of these are likely to be used or reported. Absolute fit indices measure how well the researchers' theoretical model matches the obtained data. The Chi-square (CMIN) value and the probability or associated p-value are the sole statistically based fit measures, and they should not be statistically significant with respect to the fit model. However, the X^2 statistic is very sensitive to sample size and is no longer relied upon as a basis for model acceptance or rejection (Schlermelleh-Engel et al. 2003, Vandenberg 2006). Chi-square statistic and p-value obtained in this study was 2/df = 1.331, ($p < 0.05$). This value indicates that the model has a good fit index. In CFA analysis, the RMSEA index must have a value of 0.05 or less which indicates that the model has a good fit with the data. In this study, the RMSEA value was 0.025, which can be considered acceptable.

In addition, the results of CFA obtaining GFI, AGFI, RMR are 0.981, respectively; 0.968; 0.022 which can be stated that the data-model fit is acceptable. Getting a CFI (Comparative Fit Index), NFI (Normed Fit Index) and IFI (Incremental Fit Index) value of more than 0.95 is an indicator of a perfect fit between the model and the data (Bentler, 1990; Hu & Bentler, 1999). The results of the analysis determine CFI, NFI, and IFI are 0.91, 0.988, respectively; 0.954; 0.937 which can be considered as an acceptable model. As a result, the almost perfect fit between the model derived from the CFA and the data can be highlighted in this study. Figure 1 shows a structural model of science teacher candidates' scientific attitudes. Based on the results obtained from the analysis of EFA and CFA, the scientific attitudes of prospective students of Mathematics and Natural Sciences teachers can be categorized based on the 4-factor structure as shown in table 6.

Factor	Item
Factor 1: Science is about understanding, explaining, and aiming to help other people live better.	15. Scientists discover laws or theorems that tell us what happens in the universe 23. People should understand science because it affects their lives 28. Science tries to explain how things happen 31. The ultimate goal of science is to help people live better
Factor 2: I want to be a scientist	22. I don't want to be a scientist 27. I enjoy working with scientists to solve scientific problems/problems 1. I enjoy studying science
Factor 3: Scientist's Tasks	39 .Scientists must study hard 25. Scientists must properly report what they observe
Factor 4: Science is rigid	6. Only highly trained scientists can understand science 7. We can always get answers to our questions by asking a scientist 5. If a scientist says an idea or finding is true, all other scientists will believe it

Furthermore, the analysis of the characteristics of the scientific attitude of prospective science teacher can be observed in table 5. Based on the data in the table, it can be understood that factor 3 and factor 1 are the dominant scientific attitudes possessed by students, followed by factor 2 and factor 4. This indicates that students who are prospective teachers of Mathematics and Natural Sciences FKIP University of Lampung are dominantly able to understand that science is about understanding, explain, and aim to help other people's lives better, as well as what a scientist must have. As a prospective teacher studying Mathematics and Natural Sciences, the students as the sample of this research understand the nature of science itself. However, when asked whether they wanted to be scientists (factor 2) and science was rigid (factor 4), this did not really concern them. This is understandable because the research sample was educated to become a MIPA teacher (educator) not as a researcher in the field of science, so factor 2 and factor 4 tend not to be the dominant scientific attitude for prospective students of Mathematics and Natural Sciences FKIP Unila teacher.

▪ CONCLUSION

Based on the research that has been done, several conclusions have been obtained, namely factor 3 and factor 1 as the dominant scientific attitude possessed by students, followed by factor 2 and factor 4. The scientific attitude of prospective Science teacher at the University of Lampung is dominated by the understanding that science is about understanding and explaining scientific facts and obligations of a scientist. But they themselves do not really take the attitude as a scientist. Based on the analysis of EFA and CFA, scientific attitude consists of 4 main factors, namely (a) science is about understanding, explaining, and aiming to help other people's lives better, (b) I want to be a scientist, (c) the task of a scientist and (d)) science is rigid. The structural model was declared valid, and according to the model fit index, namely $\chi 2$ / df, GFI, AGFI, RMR, RMSEA, CFI, NFI, and IFI respectively were 1.331/($p < 0.05$); 0.981; 0.968; 0.022; 0.025; 0.91, 0.988; 0.954; 0.937.

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