EXPLORATORY FACTOR ANALYSIS OF SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS CAREER INTEREST FOR PRE-SERVICE MATH AND SCIENCE TEACHERS: A CASE OF LAMPUNG UNIVERSITY, INDONESIA

By Sunyono

PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

ANÁLISE DE FATORES EXPLORATÓRIOS DO INTERESSE DE CARREIRA DE CIÊNCIA, TECNOLOGIA, ENGENHARIA E MATEMÁTICA PARA FUTUROS PROFESSORES DE MATEMÁTICA E CIÊNCIA: UM CASO DA UNIVERSIDADE DE LAMPUNG, INDONÉSIA

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RESUMO

A abordagem de aprendizado CTEM (Ciência, Tecnologia, Engenharia e Matemática) integra quatro disciplinas, a saber, ciência, tecnologia, engenharia e matemática na resolução de problemas da vida cotidiana e no fornecimento de muitas experiências de aprendizado aos alunos. Este estudo teve como objetivo analisar o interesse profissional no campo de CTEM para futuros professores indonésios de Matemática e Ciências Naturais (MIPA), estudando os padrões de relacionamento entre fatores, níveis de preferência e quais fatores o influenciam. A amostra da pesquisa foi de 300 futuros professores do MIPA na Faculdade de Formação e Educação de Professores da Universidade de Lampung. Este trabalho envolveu várias etapas como (1) adaptação e transliteração dos instrumentos de interesses de carreira STEM com base em fontes da literatura, (2) análise da validade do conteúdo com base no julgamento de especialistas, (3) disseminação de ferramentas para amostras de pesquisa e (4) avaliação de resultados de pesquisa, avaliação bivariada correlações e o nível de preferência de interesse. Os dados obtidos foram analisados estatisticamente utilizando técnicas de análise fatorial exploratória e confirmatória, análise de confiabilidade e variância e correlação produto-momento de Pearson. Os resultados da pesquisa mostraram que as informações referentes aos itens do questionário foram agrupadas em quatro fatores: atitude na carreira de engenharia, atitude na carreira em matemática, atitude na carreira em ciências e atitude na carreira em tecnologia com fatores de carga que variando de 0,575 a 0,848. Todos esses fatores foram capazes de explicar a atitude profissional da CTEM na soma de 62,43%. A atitude profissional em ciências e matemática é a preferência dominante para os futuros alunos de professores de Matemática e Ciências Naturais terem uma carreira no futuro. Além disso, os instrumentos utilizados são válidos e confiáveis para serem usados para analisar as atitudes profissionais de CTEM nos candidatos a professores de Matemática e Ciências Naturais.

Palavras-chave: *Interesses de carreira CTEM, candidatos a professores do MIPA, Universidade de Lampung.*

ABSTRACT

STEM (Science, Technology, Engineering, and Math) learning approach integrates four disciplines, namely science, technology, engineering, and mathematics, in solving everyday life problems and giving many learning experiences to students. This study aimed to analyze career interest in the field of STEM for prospective Indonesian Mathematics and Natural Sciences (MIPA) teachers, studying the patterns of relationships between factors, preference levels, and what factors influence it. The research sample was 300 prospective MIPA teachers at the Faculty of Teacher Training and Education, Lampung University. This work involved several stages as (1) adapting and transliterating STEM career interests instruments based on literature sources, (2) analyzing content validity based on expert judgment, (3) spreading tools to research samples and (4) evaluating research data results, assessing bivariate correlations, and the level of interest preference. The data obtained were analyzed statistically using exploratory and confirmatory factor analysis techniques, reliability and variance analysis, and Pearson product-moment correlation. The research results showed information regarding the items in the questionnaire were grouped into four factors, namely engineering career attitude, mathematics career attitude, science career attitude, technology career attitude with loading factors ranging from 0.575 to 0.848. All these factors were able to explain the career attitude of STEM to the sum of 62.43%. The science and mathematics career attitude is the dominant preference for prospective students of Mathematics and Natural Sciences teachers to have a career in the future. Furthermore, the instruments used are valid and reliable to be used to analyze

STEM career attitudes for Mathematics and Natural Sciences teacher candidates.

Keywords: *STEM career interests, MIPA teacher candidates, Lampung University.*

1. INTRODUCTION:

STEM education is a learning approach that integrates four disciplines, namely science, technology, engineering, and mathematics, to solve problems in everyday life (Lin *et al.*, 2015; Jurdak, 2016; Shahali *et al.*, 2016; Tsai *et al.*, 2017; Gullen, 2018; Thibaut *et al.*, 2018; Chai,2019). The learning curricula in several developed countries starting from elementary school to tertiary level nowadays have adopted the STEM approach because it is believed that this approach can provide a lot of learning experiences to students (Stohlmann, 2011; Pinnel, 2013; Barrak & Assal, 2018; Garner *et al.*, 2018, Roberts *et al.*, 2018; Bennett & Saunders, 2019; Morris *et al.*, 2019; Tytler *et al.*, 2019; Wu *et al.*, 2019). The continued application of the STEM approach in the learning process is believed to be able to shape and strengthen student character as a problem solver who is better, independent, innovative, inventive, creative, logical thinker, critical, and technology literate (Wells, 2019; Ibáñez, & Delgado-Kloos, 2018; Morrison, 2006). Moreover, STEM education positively impacts students' attitudes and interests in school (Bragow, Gragow & Smith, 1995), motivates students to learn (Gutherie, Wigfield & Von Secker, 2000) and improves student learning achievement (Hurley, 2001). Compared to teaching four disciplines as separate and discrete subjects, STEM integrates these disciplines into a cohesive paradigm based learning based on real-world applications (Hom, 2014).

Recently, the demand for a workforce well educated in science, technology, engineering, and math (STEM) is growing to stimulate economic growth and enhance innovation. The positive impact of the STEM approach to the learning process should be able to influence and enlarge the interest of students who will graduate vocational schools or students who will graduate from undergraduate to continue their education and/or have a career in the STEM field. However, many countries in the world face difficulties in carrying out the task of recruiting more people into science, the technology industry, engineering, and mathematics (STEM) (Hill *et al.* 2010; Regisford, 2012). The government, observers, and education practitioners want the STEM education curriculum to be able to internalize STEM values in student life to encourage increased student interest in a career in the field of STEM after graduating from college. Especially as prospective MIPA teachers, it is hoped that they will have careers in the STEM field after graduation.

Several studies have examined STEM career interests at various levels of education ranging from elementary (Kim *et al.*, 2015; Campbell *et al.*, 2017; Peterson, 2018; Toma & Greca, 2018), intermediate (Aeschlimann, Herzog & Makarova, 2016; Kier *et al.*, 2014; Sadler, 2014; Robnett, & Leaper, 2013), and higher education levels (Beier *et al.*, 2019; Moakler & Kim, 2014). Knowledge about STEM career interests of teacher candidates can help researchers, teachers, government, and other education stakeholders to map their career tendency and create innovative learning strategies.

This study aimed to analyze the STEM career interest of prospective math and science teacher at Lampung University.

2. MATERIALS AND METHODS:

2.1. Research Sample

This study used a traditional survey method involving 300 students (269 female and 31 male) in which all participants agreed to spontaneously participate in this study once there is no official document demanded by the University to this kind os study. Participants were active students of Mathematics and Natural Sciences (physics, chemistry, biology) Education in the Department of Mathematics and Natural Sciences, Lampung University. The survey research design is a procedure in quantitative research in which the researcher surveys the sample to describe the attitudes, opinions, behavior, or characteristics of the population (Creswell, 2012).

2.2. Instrument

The instrument (survey) was adapted from the STEM Career Interest Survey (STEM-CIS) instrument developed by Kier *et al.* (2014). The instrument was adapted and transliterated into Indonesian, making it easier for research subjects to understand each item in the instrument. The instrument was then converted into a *google form* to make it easier for students to access, easy to collect data, and paperless.

This 5-point Likert scale questionnaire consists of four dimensions or variables, namely career interests in the fields of science, mathematics, technology, and engineering, where each size includes eleven items. The full detail of the questionnaire is presented in Appendix 1.

2.3. Data Collection Technique and Analysis

The data collection technique is a conventional survey technique through the distribution of a questionnaire instrument to each sample. The students are asked to access the Google form website page, fill in questions in the form of a 5-Likert scale, and submit the results of their answers online.

Subsequently, the construct validity of the instrument used was determined for the data obtained using the exploratory factor analysis technique (EFA) using SPSS software version 23. Exploratory factor analysis (EFA) was carried out to uncover factor structures and correlation patterns between the observed variables (questionnaire items) and latent variables, which were considered as hidden variables representing these items.

Before further EFAs are carried out, it must first be tested against a group of data obtained, whether it is suitable for analysis by EFA. This can be done by observing the value of the Kayser-Mayer-Olkin (KMO) sampling adequacy test and the Bartlett sphericity test. The Kaiser-Meyer-Olkin (KMO) test is a measure of how well the data fit for Factor Analysis. This test measures the adequacy of the sample for each variable in the model and the complete model. Statistics is a measure of the proportion of variance between variables that might be general variance. The lower the balance, the more your data fits in with Factor Analysis.

Meanwhile, the Bartlett sphericity test is used to compare the obtained correlation matrix (in this case, the Pearson correlation matrix) with the identity matrix. In other words, the Bartlett test checks whether there is redundancy between variables, which can be summarized by several factors. The Bartlett test is also able to identify unrelated variables and is therefore not suitable for structural detection. Small values (less than 0.05) of the significance level indicate that factor analysis might yield useful information with the data used.

The validation criteria in the EFA analysis are based on Stevens (2002), where items retained in the instrument must have a loading factor more than 0.40, so items with a loading factor less than 0.40 will automatically be eliminated in the analysis of each item in the instrument. The principle of extraction of the main components with orthogonal rotation was used to estimate the number of possible factors while contributing to the construct validity in the developed instrument.

The reliability test for each dimension in the instrument is based on Cronbach's alpha coefficient calculation. Furthermore, determining the level of preference of STEM career interest (according to their perceptions) is conducted by determining the mean and standard deviation for each dimension and comparing them to the grand mean scores. The correlation of each dimension of STEM career interest is conducted by using the Pearson product-moment analysis.

3. RESULTS AND DISCUSSION:

The KMO and Bartlett chi-square test values obtained were 0.937 and 11872.889 ($p < 0.05$), as shown in Table 1. These values indicate that the research data are suitable for use in the EFA analysis and are expected to provide useful interpretation.

After finding out that the research data obtained was ideal for EFA analysis, an investigation was carried out on the value of extraction commonalities. Communalities shows the amount of variance in each variable that is considered. Initial communalities are estimates of variation in each variable recorded by all components or factors. For central component extraction, this is always equal to 1.0 for correlation analysis. Meanwhile, Extraction communalities are estimates of the variance in each variable that is taken into account by the component. Communalities have high enough extraction values ranging from 0.611 to 0.787, which shows that the components extracted represent the variables well (Table 2)

The researcher makes a limitation that items that can be accepted to represent latent factors are items that have a loading factor of more than 0.40, according to Stevens (2002) criteria. Stevens (2002) suggested that retained questions in the questionnaire must have a loading factor of more than 0.40. This has implications for the removal of items that have a loading factor of less than 0.40. The principle of extracting major components with orthogonal rotation was used in this study to estimate the number of possible factors while contributing to the construct validity in the scientific attitude instruments developed. From the results of the EFA analysis, it was found that the items clustered into four main factors, with loading factors ranging from 0.575 to 0.848. Meanwhile, eight items were excluded from the EFA analysis due to factor loading values below 0.40. Furthermore, each factor can be declared reliable based on Cronbach's alpha complete information is 0.980, which indicates that the factors in the instrument have a high level of internal consistency to evaluate the attitude of prospective MIPA teachers for a career in the STEM field (Table 3).

3.1. Attitude level towards STEM careers

The STEM career attitude level analysis was conducted by comparing the mean values obtained for each latent factor against the grand mean, according to Suprapto (2016). A mean value more significant than the dignified way is seen as a dominant tendency for STEM careers in prospective MIPA teacher candidates. From the data in Table 4, information is obtained that science and mathematics have a mean value more significant than the grand mean. These results indicate that science and mathematics are the dominant tendencies of the attitude of prospective MIPA teacher students compared to technology and engineering.

3.2. Correlation between factors

Correlation analysis between factors was conducted by taking into account the Pearson product-moment correlation coefficient. From the results of the correlation analysis, information is obtained that all factors correlate significantly with a 99% confidence level (Table 5)

A factor analysis technique was used to identify structural factors of the attitude of the prospective MIPA teacher students to have a career in STEM. In general, the instruments have high validity and reliability for measuring the positions of prospective MIPA teacher students to pursue careers in the STEM field. The STEM career attitude instrument consists of 36 statement items in which these items can explain 62.437% of STEM career attitudes with a breakdown of 17.320%; 15.842%; 15.105%; and 14.171% for careers in science, mathematics, technology, and engineering. The results of this study also provided information that the attitude of the prospective MIPA teacher students for a career in the STEM field can be classified into four main factors, namely:

a. Science career attitude (factor 1) consisting of 9 items ($\alpha = 0.917$; $s^2 = 7.320\%$); explore the position of prospective MIPA teacher students to pursue careers in the field of science such as science assignments and study at school, interest in working in the sciences, and seriousness in science courses.
b. Mathematics career attitude (factor 2) consisting of 9 items ($\alpha = 0.927$; $s^2 = 15.842\%$); explore the attitudes of prospective MIPA teacher students to pursue careers in the field of mathematics such as mathematics assignments and learning in school, interest in working in mathematics, and seriousness in mathematics courses.
c. Technological career attitude (factor 3) consisting of 9 items ($\alpha = 0.911$; $s^2 = 15.105\%$); explore the perspectives of prospective MIPA teacher students to pursue careers in technology such as assignments and technology learning at school, interest in working in technology, and seriousness in technology courses.
d. Engineering career attitude (factor 4) consisting of 9 items ($\alpha = 0.936$; $s^2 = 14.171\%$); explore the perspectives of prospective MIPA teacher students to pursue careers in engineerings such as assignments and learning about engineering at school, interest in working in engineering, and seriousness in engineering courses.

Out of the four STEM career attitudes, the majority of MIPA teacher candidates prefer a career in the fields of mathematics and science over technology and engineering. This is indicated based on the mean value of the career of science and mathematics is higher than the value of the grand mean compared to technology and engineering. This certainly can be understood based on the specialization curriculum pursued by prospective MIPA teacher students, where most of the courses are dominated by science and mathematics. At the same time, classes that contain technological and engineering content will certainly not be too dominant. The results of the Pearson product-moment correlation analysis illustrate that each factor or dimension of STEM career attitudes correlates with each other significantly with a 99% confidence level. This result can be understood because STEM attitudes are indeed associated with each other, like the results of research from Suprapto (2016). Hence it does not rule out that STEM career attitudes will also influence each other.

The results of this study are consistent with previous studies that found that there is a positive impact of the STEM approach to the learning process, which affects and increases the interest of students of vocational schools or undergraduate program students to continuing education and/or have a career in the field of STEM (Business Europe, 2011; Healy *et al*., 2011). Besides, other studies have found that STEM education can have a direct impact on learning, both in schools and in universities. STEM education encourages the formation and strengthening of the character of students to be able to solve problems, be independent, thinkers, and, most importantly, be literate in technological literacy (Wells, 2019; Morrison, 2006). Thus, the results of this study are expected to have a positive impact on making changes to the curriculum in the department of mathematics and natural science education in fostering career spirit and motivation in STEM students.

4. CONCLUSIONS:

Exploratory and reliability analysis revealed that the instrument used in this study had high internal consistency and was able to explain more than half of the overall STEM attitudes of MIPA teacher candidates. This indicates that the instrument is appropriate to be used for analyzing students' career interests in the STEM field and reasonably pleasant to explain the students' tendency to have a STEM career after graduating from college.

Moreover, the second aim of this study was to investigate which preference is more dominant among the four STEM fields. Mean, and grand mean comparison analysis revealed that science and mathematics career attitudes become the prevailing preference for the future career of prospective MIPA teachers. This indicates that working in the fields of science and mathematics is more desirable than technology and engineering;

The last, Pearson product-moment analysis confirmed that all factors significantly correlate with each other. It means that efforts to improve one dimension of STEM career attitudes will directly impact on improving career attitudes in different dimensions, and vice versa.

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APPENDIX 1

STEM Career Interest Survey (STEM-CIS)

Science (S)

S1 I am able to get a good grade in my science class.
S2 I am able to complete my science homework.
S3 I plan to use science in my future career.
S4 I will work hard in my science classes.
S5 If I do well in science classes, it will help me in my future career.
S6 My parents would like it if I choose a science career.
S7 I am interested in careers that use science.
S8 I like my science class.
S9 I have a role model in a science career.
S10 I would feel comfortable talking to people who work in science careers.
S11 I know of someone in my family who uses science in their career.

Mathematics (M)

M1 I am able to get a good grade in my math class.
M2 I am able to complete my math homework.
M3 I plan to use mathematics in my future career.
M4 I will work hard in my mathematics classes.
M5 If I do well in mathematics classes, it will help me in my future career.
M6 My parents would like it if I choose a mathematics career.
M7 I am interested in careers that use mathematics.
M8 I like my mathematics class.
M9 I have a role model in a mathematics career.
M10 I would feel comfortable talking to people who work in mathematics careers.
M11 I know someone in my family who uses mathematics in their career.

Technology (T)

T1 I am able to do well in activities that involve technology.
T2 I am able to learn new technologies.
T3 I plan to use technology in my future career.
T4 I will learn about new technologies that will help me with school.
T5 If I learn a lot about technology, I will be able to do lots of different types of careers.
T6 My parents would like it if I choose a technology career.

T7 I like to use technology for class work.

T8 I am interested in careers that use technology.

T9 I have a role model who uses technology in their career.

T10 I would feel comfortable talking to people who work in technology careers.

T11 I know of someone in my family who uses technology in their career.

Engineering (E)

E1 I am able to do well in activities that involve engineering.

E2 I am able to complete activities that involve engineering.

E3 I plan to use engineering in my future career.

E4 I will work hard on activities at school that involve engineering.

E5 If I learn a lot about engineering, I will be able to do lots of different types of careers.

E6 My parents would like it if I choose an engineering career.

E7 I am interested in careers that involve engineering.

E8 I like activities that involve engineering.

E9 I have a role model in an engineering career.

E10 I would feel comfortable talking to people who are engineers.

E11 I know of someone in my family who is an engineer.

Table 1. *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.937
Bartlett's Test of Sphericity	Approx. Chi-Square	11872.898
	Df	630
	Sig.	.000

Notes: Df and Sig. are degree of freedom and significance, respectively

Table 2. *Communalities*

Item	Initial	Extraction
S1	1.000	.708
S2	1.000	.713
S3	1.000	.666
S4	1.000	.678
S5	1.000	.687
S6	1.000	.709
S7	1.000	.721
S8	1.000	.709

S10	1.000	.668
M1	1.000	.750
M2	1.000	.769
M3	1.000	.749
M4	1.000	.736
M5	1.000	.699
M6	1.000	.699
M7	1.000	.789
M8	1.000	.728
M10	1.000	.695
T1	1.000	.623
T2	1.000	.724
T3	1.000	.662
T4	1.000	.661
T5	1.000	.706
T6	1.000	.683
T7	1.000	.594
T8	1.000	.616
T10	1.000	.611
E1	1.000	.750
E2	1.000	.737
E3	1.000	.735
E4	1.000	.724
E5	1.000	.684
E6	1.000	.634
E7	1.000	.772
E8	1.000	.787
E10	1.000	.666

Extraction Method: Principal Component Analysis.

Table 3. *Loading factor and variance for each factors and items*

Item	Factor 1 (α = 0.917; s^2 = 17.320%)	Factor 2 (α = 0.927; s^2 = 15.842%)	Factor 3 (α = 0.911; s^2 = 15.105%)	Factor 4 (α = 0.936; s^2 = 14.171%)
E8	.848			
E7	.833			
E3	.782			
E1	.741			
E2	.738			
E10	.738			
E6	.734			
E4	.704			
E5	.655			
M7		.855		
M3		.841		
M8		.824		
M1		.751		
M2		.716		
M4		.714		
M6		.713		
M10		.710		
M5		.670		
S7			.781	
S8			.767	
S3			.757	
S5			.732	
S6			.721	
S10			.713	
S4			.696	
S2			.613	
S1			.573	
T6				.717
T4				.711
T2				.702
T5				.699
T8				.695
T3				.671
T1				.658
T7				.654
T10				.585

Notes: Factor 1, Factor 2, Factor 3, and Factor 4 are Science career attitude, Mathematics career attitude, Technology career attitude, and Engineering career attitude, respectively

Table 4. *Degree of STEM career interest*

	Mean	Std. Deviation	Rank*
Science	3.849	.642	2
Math	3.853	.604	1
Technology	3.813	.609	3#
Engineering	3.768	.593	4#

*Grandmean = 3.821; #nilai mean < grandmean

Table 5. *Interrelationship between factors STEM career interest*

	Science	Math	Technology	Engineering
Science	1	.965**	.960**	.877**
Math		1	.978**	.947**
Technology			1	.956**
Engineering				1

**. Correlation is significant at the 0.01 level (2-tailed).

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ORIGINALITY REPORT

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