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ATITUDE PARA A TECNOLOGIA PARA PROFESSORES DE CIÊNCIA EM TREINAMENTO NA INDONÉSIA: UMA ANÁLISE DE FATOR EXPLORATÓRIO

ATTITUDE TOWARDS TECHNOLOGY FOR PRE-SERVICE SCIENCE TEACHERS IN INDONESIA: AN EXPLORATORY FACTOR ANALYSIS

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RESUMO

O conhecimento e a habilidade tecnológica são cruciais para professores e professores em treinamento, pois afetam diretamente o desempenho, a qualidade da aprendizagem e o acesso mundial mais amplo. Muitos estudos mostraram que a capacidade de um professor em pedagogia integrada à tecnologia é influenciada por sua atitude em relação à tecnologia. O objetivo deste estudo foi utilizar a análise fatorial exploratória para examinar os fatores estruturais, o nível de preferência e a inter-relação entre os componentes da atitude em relação à tecnologia. Os dados foram coletados de 150 professores de ciências em serviço da Universidade Lampung usando o método tradicional de pesquisa. Além disso, foram analisadas variância, comparação de valores médios e coeficientes de Alfa de Cronbach para explicar as contribuições de itens e fatores para a atitude geral em relação à tecnologia. A análise de correlação de Pearson também foi realizada para descobrir a relação entre os componentes. Os resultados confirmaram a validade do instrumento com fatores de carga variando de 0,427 a 0,882. Além disso, o coeficiente total de Cronbach Alpha foi de 0,810, o que informou uma alta consistência interna do instrumento, com cinco componentes de atitude tecnológica, responsáveis por 77,82% da variância. Especificamente, a consequência percebida da tecnologia é identificada como uma preferência atitudinal dominante dos professores de ciências em serviço na Indonésia, seguidos pelas aspirações de carreira e pela diferença de gênero. A análise do momento do produto Pearson revelou uma correlação significativa entre os componentes da atitude em relação à tecnologia.

Palavras-chave: *Atitude em relação à tecnologia; Professor de ciências em treinamento; Análise fatorial exploratória.*

ABSTRACT

Technological knowledge and skill are crucial for teachers and pre-service teachers because they have a direct effect on performance, learning quality, and wider world access. Many studies showed that the ability of a teacher in technology-integrated pedagogy is influenced by their attitude towards technology. The aim of this study was to use exploratory factor analysis in examining the structural factors, the preference level and the interrelationship among components of attitude towards technology. Data was collected from 150 pre-service science teachers in Lampung University by using traditional survey method. Additionally, variance, mean values comparison, and Cronbach Alpha coefficients were analyzed in explaining the contributions of items and factors to the overall attitude towards technology. Pearson correlation analysis was also conducted to find out the relationship among components. The results confirmed the validity of instrument with loading factors ranging from 0.427–0.882. In addition, the total Cronbach Alpha coefficient was 0.810 which informed a high internal consistency of instrument with five components of technological attitude account for 77.82% of variance. Specifically, the perceived consequence of technology is identified as a dominant attitudinal preference of pre-service science teachers in Indonesia, followed by career aspirations and gender difference. Pearson product-moment analysis revealed a significant correlation among components of attitude towards technology.

Keywords: *Attitude toward technology; Pre-service science teacher; Exploratory factor analysis.*

1. INTRODUCTION

The rapid development of technology has become a major concern for all elements of society. People in any profession are aware of the great role of Information and Communication Technology (ICT) of the ease of life and national development. In education, ICT mastery is prominent for teachers and pre-service professional teachers in the era of the industrial revolution 4.0. (Warschauer & Matuchniak, 2010). The integration of ICT in learning is an essential strategy in facilitating the shifting from traditional pedagogical paradigms towards constructivist-oriented pedagogies (Chai, Hong & Teo, 2009; Liu, 2011; Keengwe & Georgina, 2013).

By integrating technology, teachers can easily direct students to imagine the complex objects (Tania & Saputra, 2018; Tania et al., 2017; Sang et al., 2010), interpret the abstract concept to concrete things (Sunyono, Tania, & Saputra, 2016; Lee, 2012; Bujak et al., 2013; Wojciechowski & Cellary, 2013), also actively participate in collaborative activities in virtual classes or e-learning schemes (Holcomb & Beal, 2010, Keengwe et al., 2014). The use of various innovations and technology by teachers will lead to higher confidence in integrating technology-pedagogy (Kim et al., 2013; Rienties, Brouwer, & Lygo-Baker 2013), facilitating collaboration between colleagues (Afshari et al., 2009; Ottenbreit-Leftwich et al., 2010; Kim et al., 2013; Tomkins, 2019), and bringing up new innovative ideas (Koehler & Mishra, 2009; Mayer, 2012; Laurillard, 2013). Finally, the application of technology and multimedia in the teaching-learning process can help students enhance their academic achievement (Chiang, Yang, & Hwang, 2014; Alqahtani & Mohammad, 2015) and encouraging students' motivation and confidence in learning (Hazari, North, & Moreland, 2009; Yang & Wu, 2012; Chiang, Yang, & Hwang, 2014).

Recognizing the important role of technology in achieving learning objectives, a professional teacher must take a vital role in teaching, guiding, and motivating in the accomplishment of ICT-integrated learning (Kramarski & Michalsky, 2010; Gilakjani, Lai-Mei, & Ismail, 2013). A research conducted by Hattie (2003) revealed that teacher's effectiveness contributes up to 30% of variance in student achievement, 50% of variance for pre-existing student abilities, and the remaining 20% of variance is influenced by home, school (including administration), and peers. Based on this data, teachers who use student-centered approaches and have good classroom management competencies will increase student achievement to the maximum (Opdenakker & Van Damme, 2006). Furthermore, a competent teacher is characterized by how often she/he uses ICT in multiple ways in the classroom (Whittle Telford, & Benson, 2018).

There are a couple of factors for teachers in integrating ICT into their learning which can be categorized as external and internal factors. External factors include professional teacher development and training, administrative support, positive school environments, adequate technological resources, technology access, technical assistants, adequate planning time, sustained funding for technology, and instructional styles (Eteokleous, 2008). Additionally, the attitude of the principal (Coffland& Strickland, 2004), colleague influences (Oncu, Delialioglu, & Brown, 2008), and parental involvement (Baek, Jong, & Kim, 2008) are also included as external factor. Meanwhile, internal factors include attitudes toward learning, pedagogical beliefs, and personal characteristics (Eteocleous, 2008), individual mindset and teacher's belief (Liu, 2011).

Attitude is undeniably one of the internal factors that greatly determine the success of technology integration in the teaching-learning process. Teo (2008) states that the way teachers use technology for instructional design is very dependent on their attitude toward technology. Despite of the qualified technological tools provided by the school provided, it can only be optimized if the teacher has a positive attitude towards it (Huang & Liaw, 2005). A positive teacher attitude towards technology will be a determining factor for the successful adoption and integration of technology in the teaching and learning process (Van Braak et al., 2004; Huang & Liaw, 2005). Conversely, teachers who have a negative attitude towards the use of ICT will tend to be difficult to accept and adapt technology in their instructional design (Wang & Dostál, 2017).

In particular, Bame et al. (1993) has constructed structural factors of Pupils' Attitude

Towards Technology USA (PATT-USA) Survey (de Vries, 1988). Items of PATT-USA are grouped into 5 dimensions i.e. Career Aspirations, Interest in Technology in Schools, Perception of Consequences of Technology, Difficulty of Perception, and Technology as a Subject for Both Genders (Bame et al., 1993). However, Ardies, de Maeyer, & Gijbels (2013) reconstructed the PATT-survey by adding one more dimension in the mediated boredom of technology. By using this PATT-reconstructed survey, this research investigated attitude towards technology of pre-service Indonesian science teachers. Furthermore, information related to the structural factors was used to discuss the preference level of students towards factors and interrelationship among factors.

2. MATERIALS AND METHODS

2.1 Research Design and Participants

This research used a conventional survey design by distributing questionnaires to pre-service science teacher in Lampung Province, Indonesia. Survey research is a procedure in quantitative research in which the researcher conducts a survey of the sample to describe the attitudes, opinions, behavior or characteristics of the population (Creswell, 2012). Furthermore, survey methods have been effectively used to express attitudes towards technology and perceptions of technology implementation in teaching and learning (Norton, McRobbie, & Cooper, 2000; Baek, Jong, & Kim, 2008). The population in this research was pre-service science teachers from the Department of Chemical Education, Physical Education, and Biological Education, Faculty of Teacher Training and Education, University of Lampung. In addition, 150 pre-service science teachers were chosen as research sample by using random sampling technique. Everyone who became a sample filled agreement to participate in this research.

2.2 Instrument and Data Collection

The data collection technique in this research was using attitude towards technology questionnaire (Appendix 1) developed by Ardies, de Maeyer, & Gijbels (2013) which originally consisted of 25 items. The instrument was adapted and transliterated into the Indonesian language (Bahasa), making it easier for research subjects to understand each item in the instrument. Items are then consulted and validated by the judgement of three experts in the field of statistics, psychologists, and education evaluation experts. Furthermore, all items were inserted into google form to facilitate participants in accessing the questionnaire and to simplify the data tabulation.

2.3 Data Analysis

Data analysis in this research was carried out into several stages. In the initial stage, students' answers were coded into 5 levels of Likert scale. The coding results were analyzed whether the data was suitable for EFA based on the Kaiser-Mayer-Olkin (KMO) sampling of adequacy and Bartlett's test of sphericity. Before the EFA process was carried out, the communality coefficient of each item identified would be considered as included in the analysis based on Stevens's (2002) criteria. Items that are maintained in the instrument must have a loading factor of more than 0.40, therefore items with a loading factor of less than 0.40 will automatically be eliminated in the analysis of each item in the instrument. If all of these preliminary procedures have been passed then an EFA can be performed. The estimation of latent factors number proposed in this study was obtained by extracting the main components and of the varimax orthogonal rotation by considering an eigenvalue which is greater than one. In order to obtain the reliability of each factor and total Cronbach Alpha coefficient was used to calculate the validated construction instrument. In addition, the mean and standard deviation were calculated to obtain information related to the dominant preference for the factors forming the technology attitude. In the final stage, correlation analysis of each factor was carried out using the Pearson correlation coefficient.

3. RESULTS AND DISCUSSION

3.1 Structural analysis of attitude towards technology

The results of this study consisted of two parts i.e (a) structure analysis of attitude towards technology and (b) level of preference and interrelationship between attitude dimensions. Structure analysis was carried out by using exploratory factor analysis in which statement items in the questionnaire will be grouped and validated into certain factors based on appropriate statistical criteria. Exploratory factor analysis (EFA) was a statistical method used to reveal the basic structure of variables and identify the fundamental relationships between variables.

All measured variables correspond with each latent variable (Schmitt, 2011; Treiblmaier & Filzmoser, 2010). To ensure the EFA results, calculation to Kayser-Mayer-Olkin (KMO) measure of sampling adequacy and Bartlett test of sphericity were used. The KMO test was performed to analyze the suitability of the data for factor analysis by measuring the shared variance in the items (Beavers et al., 2013). The lower the KMO test value, the more suitable the data for factor analysis. Moreover, the Bartlett test of sphericity was used to check whether the correlation matrix was an identity matrix. This method was able to inform variables which were not related and suitable for structural factors (Beavers et al., 2013).

The KMO and Bartlett test values in this study were 0.853 and 2157.349 ($p < 0.05$) respectively, which indicate that a set of research data was suitable for EFA and would produce accurate analysis results. Subsequently, it was necessary to inspect whether all items could be included in the EFA analysis or need to eliminate certain items in the analysis process. This could be done by observing the coefficient of extraction commonalities. Extraction communalities are estimations of variance for each variable that can be explained by factors in a factor solution (UCLA Statistical Consulting Group, 2019). Small values of the commonalities coefficient indicated that variables did not match factor solutions, and may considered to be excluded from the next analysis. Steven (2002) suggested that the threshold value of the communality was 0.40 to determine which items were retained or excluded in EFA. The communality coefficient was greater than 0.40 indicates that the item contributed significantly to latent variables in producing a fit model. Furthermore, item number 10 (I enjoy repairing things at home) has a coefficient of 0.318, it means that the commonality analysis needs to be repeated by removing the item. In the second commonality analysis, it was obtained coefficients ranging from 0.410 – 0.852 which informed that only 23 items could be considered for the EFA analysis.

The verified items were further analyzed by using varimax rotation method and principal component extraction with eigenvalues larger than one for all accepted factors. The results suggested that items were distributed into 5 latent factors with 77.82% of total variance explained (s^2) as shown in Table 1. This construction was different from the result of Ardies et al. (2013) who obtained six factors of technological attitude. The current study found out that the items concerning interest in technology proposed by Ardies's research spread to two factors, namely technological career aspirations and consequence of technology. Full details of the factors are presented as follows:

1. Factor 1 (s^2 = 18.972%) was named technological career aspirations (TCA). It accommodated 6 items exploring job and career ambition in technology, interest concerning work in technology, and interest concerning technology lesson at school.
2. Factor 2 (s^2 = 16.581%) was named as perceived consequence of technology (PCT). It accommodates 6 items exploring the importance of technology and technology lessons, the advantage of technological use at work, interest in technology and technology lessons at school.
3. Factor 3 (s^2 = 13.093%) was named as tediousness towards technology (TTT). It accommodates 4 items exploring technological jobs, hobbies, and machines are boring.
4. Factor 4 (s^2 = 15.554%) was named technology as a subject for both boys and girls (TBG). It accommodates 3 items exploring gender differences in technology.
5. Factor 5 (s^2 = 13.620%) was named as label perceived difficulty of technology (PDT). It accommodates 4 items exploring prerequisites to study technology.

Each item has an absolute value of the loading factor ranging from 0.427–0.882 as shown in table 2. This value meets the criteria of Steven (2002) whereas items retained in factor analysis must have a loading factor greater than 0.4. This result was also supported by reliability analysis using Cronbach's alpha coefficients, while the scores for each factor are 0.753, 0.861, 0.830, 0.796 and 0.755, respectively with 0.810 as the overall coefficient. These indicate that the loading factors have a high internal consistency to evaluate attitudes of teachers' candidates towards technology.

3.2 Preference level and Interrelationships among factors

The preference level analysis was carried out to get specific information related to the dominant attitudinal tendency of pre-service science teachers towards technology in Indonesia. This analysis was performed by comparing the mean values of each factor with a grand mean as suggested by Suprapto (2016). The result of the analysis claimed that the perceived consequence of technology was considered as the most dominant factor from technology attitude with a mean value of 4.013 and a standard deviation of 0.468. The second rank was technological career aspirations with a mean value of 3.885 and a standard deviation value of 0.681, followed by technology as a subject for both boys and girls with mean and standard deviation values of 3.080 and 1.127 respectively. These three factors had a mean value greater than the grand mean (2.960) as shown in Table 2. These findings indicated that pre-service Indonesian science teachers, in the first stage, would direct their feelings toward the positive (or negative) effects of technology on the environment and society when they decided to use or not to use technology in their instructional design. Subsequently, teacher candidates would consider how big their ambition to learn or to master technology-related jobs in the future, by including their gender aspects (Ardies et al., 2014).

The next important information is regarding the relationships among attitudinal factors towards technology. In this study, the interrelationship among factors was analyzed using Pearson product-moment correlation. Pearson correlation test was used to determine the one-on-one correlation between each dependent variable toward the independent variable. The correlation coefficients are ranging from -0.208–0.538 that useful for limited prediction (Creswell, 2012). Furthermore, one factor correlates significantly at the 0.01 and 0.05 levels with other factors as shown in table 3. The results also showed that the items questionnaire affect each other either positively or negatively. This also indicates that the efforts applied to improve an attitude component will directly strengthen or weaken another component.

This study was performed by analyzing structural factors which composed technological attitudes, followed by revealing the preference level and interrelationship among factors. These findings produce an attitude towards technology instrument which has high validity and reliability. The items and latent factors in this instrument were able to explain 77.82% of variance in attitudes towards technology. This percentage of variance meets the standard by Pett, Lackey, & Sullivan (2003) which revealed the cumulative variance extracted by successive factors should be more than 50%. Moreover, variance analysis in each factor was found that technological career aspirations as the greatest variance among others. It means that the attitude towards technology could be described by job and career ambition in technology, interest relating to work in technology, interest relating to technology lessons at school relatively more than others. As in the reliability analysis, Cronbach Alpha coefficients was 0.753; 0.861; 0.830; 0.796; 0.755 for each scale and 0.810 for the instrument overall. According to Nunnally & Bernstein (1994), the alpha values greater than 0.70 could be considered as a minimum measure of internal consistency. In other words, these factors were quite reliable in representing the overall attitudes towards technology. Based on the reliability and validity analysis above, the instrument was believed to be able to produce accurate information about attitude towards technology, especially for teachers and pre-service science teachers.

Preference level analysis based on the comparison between mean and grand mean informed three main factors of the technological attitudes for Indonesian science teacher candidates. There were perceived consequence of technology as the first rank followed by technological career aspirations, and technology as a subject for both boys and girls, respectively. As stated by Suprapto (2016), the comparison between mean and grand mean provide justification related to the degree of attitude (Suprapto, 2016). These results indicate that the pre-service teacher's attitude towards technology is primarily determined by their awareness of the importance of technology and technology education, the benefits of technology use, and interest in technology and technology lessons in schools. This finding is in line with a nationwide survey of fourth to twelfth-grade teachers in the USA by Sheingold& Hadley (1990) and found that the source of their motivation to use technology in teaching and learning were the benefits to their own learning and professional development as teacher. Furthermore, interest in technology would encourage users to intensively interact with technology and explore the use of technology in various situations (Zhao & Frank, 2003). Teachers with more computer experience were more likely to show positive attitudes towards computers (Pope-Davis &Twing, 1991; Moseley and Higgins, 1999; Rozell& Gardner, 1999; Kadijevich&Haapasalo, 2008; Teo, 2008). The next technology attitudes of pre-service science teachers were job and career ambition, interest relating to work, and gender effect in technology. Ardies, Maeyer, &Gijbels (2015), researchers in specific, have studied these factors in their longitudinal studies and concluded that career aspirations and interests in technology depends on gender and become big boosts in addressing technology integration. In addition, students' career aspirations and interests in technology are unsettled, it generally changes in the first cycle of secondary education and continues to decrease over time.

Pre-service teachers trained in Institutions for Teacher Training and Pedagogy would generally obtain courses related to content and professional knowledge integrated technology. For example ICT-based learning, virtual-based learning (e-learning), computer visualization, and various computer applications for specific subjects (for example computational chemistry, computational physics, bioinformatics, etc.). The aims were to introduce, train, and familiarize science teacher candidates in Indonesia to adopt and adapt technology in the teaching-learning process. Positive attitudes and confidence in integrating various technologies in instructional settings were expected by having more interactions and experiences with computer technology. This was also supported by Teo (2008) who surveyed the attitude of Singaporean pre-service teachers' towards computer use and found that years of computer use are positively correlated with positive computer attitudes and the level of computer confidence.

From Pearson correlation analysis, it was found that a factor correlated to each other significantly with confidence levels of 99% and 95%. These results informed that career aspirations affect perceived consequence, tediousness, perceived difficulty toward technology and all these factors could not be separated from gender difference. Several studies supported these findings by stating that attitude towards computer technology constitutes to many variables such as computer experience (Pope-Davis & Twing, 1991; Kadijevich & Haapasalo, 2008; Teo, 2008), perceived usefulness and computer confidence (Rovai & Childress , 2002; Teo, 2008), Age (Pope-Davis &Twing, 1991), gender (Pope-Davis &Twing, 1991; Sadik, 2006; Teo, 2008), training (Tsitouridou & Vryzas, 2003), and subjective norm and facilitating conditions (Teo, 2008). Therefore, all efforts by education stakeholders such as schools, government, education observers, institutions for educational quality assurance, teacher training institutions should start encouraging technology-pedagogy integration and improving technological skills for teachers and pre-service science teachers by encouraging positive attitudes towards technology. Surely, many other factors must be also considered in doing this.

4. CONCLUSIONS:

Exploratory factor analysis applied in this research provided important evidence related to the main factors that characteristically configures the attitudes of pre-service science teachers towards technology. From all factors, perceived consequence of technology, technological career aspirations, and technology as a subject for both boys and girls play an important role in attitude towards technology for Indonesian pre-service science teachers. Based on Cronbach alpha coefficients, there are significant attitudinal correlations among the factors. Finally, statistical judgments confirm that the instruments used in this study have a high validity and reliability. In addition, the evidence presented in this research are expected to be recommendations are catalyst for teachers and teacher candidates to change their mindset and encourage a positive attitude towards technology in education.

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Table 1. *Items informations, loading factor dan Cronbach α of attitude towards technology questionnaire*

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1: Technological Career Aspirations (TCA), α = 0.753, s^2 = 18.972%					
TCA1	0.879				
TCA2	0.850				
TCA3	0.801				
TCA4	0.798				
TCA5	0.645				
TCA6	0.492				
Factor 2: Perceived Consequence of Technology (PCT), α = 0.861, s^2 = 16.581%					
PCT1		0.847			
PCT2		0.800			
PCT3		0.789			
PCT4		0.529			
PCT5		-0.427			
PCT6		-0.482			
Factor 3: Tediousness Towards Technology (TTT) α = 0.830, s^2 = 13.093%					
TTT1			0.844		
TTT2			0.840		
TTT3			0.830		
TTT4			0.700		
Factor 4: Technology as a Subject for both Boys and Girls (TBG) α = 0.796, s^2 = 15.554%					
TBG1				0.882	
TBG2				0.881	
TBG3				0.815	
Factor 5: Perceived Difficulty of Technology (PDT), α = 0.755, s^2 = 13.620%					
PDT1					0.758
PDT2					0.724
PDT3					0.656
PDT4					0.606

Table 2. *The mean and standard deviation of each factor**

Factor	Mean	Standard Deviation	Ranking
1	3.885	0.681	2*
2	4.013	0.468	1*
3	1.924	0.781	4
4	3.080	1.127	3*
5	1.899	0.682	5

*mean > grand mean

Table 3. *Summary of Pearson correlation for each factors*

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1	1	0.538**	-0.403**	-0.216**	-0.273*
Factor 2		1	-0.249**	0.210*	-0.208*
Factor 3			1	0.253**	0.323**
Factor 4				1	0.345**
Factor 5					1

** $P > 0.01$; * $P > 0.05$

APPENDIX 1

Attitude Towards Technology Questionnaire

Directions:
Please tick () in the box one of the five choice (Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A) and Strongly Agree (SA) for each statement

Items	Option				
	SD	**D**	**N**	**A**	**SA**

Technological Career Aspirations

I would enjoy a job in technology					
I would like a career in technology later on					
Working in technology would be interesting					
I will probably choose a job in technology					
If there was a school club about technology I would certainly join it					
There should be more education about technology					

Perceived Consequence of Technology

Technology lessons are important					
Technology is very important in life					
Everyone needs technology					
You have to be smart to study technology					
Technology makes everything work better					
I am not interested in technology					

Tediousness Towards Technology

Most jobs in technology are boring					
A technological hobby is boring					
I think machines are boring					
I do not understand why anyone would want a job in technology					

Technology as a Subject for both Boys and Girls

Boys are more capable of doing technological jobs than girls Boys know more about technology than girls do this Boys are able to do practical things better than girls					

Perceived Difficulty of Technology

You can study technology only when you are good at both mathematics and science					
To study technology you have to be talented					
Technology is only for smart people					
I would rather not have technology lessons at school					

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