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Using an Indonesian-version of the Green Chemistry Attitude Scale to Evaluate College Students' Awareness towards Environment

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Abstract: This study aims to evaluate the concern of prospective chemistry teacher students towards the environment using a questionnaire. green chemistry attitude. The data obtained were analyzed using exploratory factor analysis (EFA) techniques to determine the contribution of each item, the level of student mastery, and the interrelationship between the dimensions of green chemistry attitudes. The research sample was 200 students who were taken by random sampling technique from the total number of students from the Department of Chemistry Education, FKIP, University of Lampung. The results showed that the 15 statement items in the instrument grouped into 4 factors, namely prevention, design for energy efficiency, safer solvent and auxiliaries, design for degradation. Each statement item and factor have a fairly good validity and reliability in terms of the standard rotated factor loadings and the Cronbach's alpha coefficient. Furthermore, the mean and grandmean analysis revealed that most of the prospective students for chemistry teacher at FKIP Unila had a positive attitude towards the concept of recycling in chemical processes and the use of solvents that were safe for the environment. Each factor also shows a strong correlation with each other in terms of the Pearson correlation coefficient. Finally, this instrument is highly recommended for further research in revealing teacher candidates' concern for the environment.

Keywords: green chemistry attitude scale, prospective chemistry teachers, factor analysis.

Abstract: *Penelitian ini bertujuan untuk mengevaluasi kepedulian calon guru kimia terhadap lingkungan dengan menggunakan green chemistry attitude scale. Data yang diperoleh dianalisis dengan teknik exploratory factor analysis (EFA) untuk mengetahui kontribusi tiap butir soal, tingkat ketuntasan siswa, dan keterkaitan antar dimensi sikap green chemistry. Sampel penelitian adalah 200 mahasiswa yang diambil dengan teknik random sampling dari total mahasiswa Jurusan Pendidikan Kimia FKIP Universitas Lampung. Hasil penelitian menunjukkan bahwa 15 item pernyataan dalam instrumen dikelompokkan menjadi 4 faktor yaitu pencegahan, desain untuk efisiensi energi, pelarut dan bahan tambahan yang lebih aman, desain untuk degradasi. Setiap item dan faktor memiliki validitas dan reliabilitas yang cukup baik ditinjau dari standard rotated factor loeading dan koefisien alfa Cronbach. Selanjutnya, analisis mean dan grandmean mengungkapkan bahwa sebagian besar calon guru kimia di FKIP Unila memiliki sikap positif terhadap konsep daur ulang dalam proses kimia dan penggunaan pelarut yang aman bagi lingkungan. Masing-masing faktor juga menunjukkan korelasi yang kuat satu sama lain dilihat dari koefisien korelasi Pearson. Terakhir, instrumen ini sangat direkomendasikan untuk penelitian lebih lanjut dalam mengungkap kepedulian calon guru terhadap lingkungan.*

Keywords: *skala sikap terhadap kimia hijau, calon guru kimia, analisis faktor.*

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▪ INTRODUCTION

Green chemistry is one of the studies in chemistry that focuses on preventing environmental pollution, both in terms of the chemicals produced, the process or the reaction steps used (Anastas & Kirchhoff, 2002; Hjeresen et al., 2000; Clark, 1999). More specifically, this concept emphasizes the use of methods and/or control of human actions by regulating all aspects and types of chemical processes in order to reduce negative effects on the environment and human health (Anastas & Kirchhoff, 2002; Wenxiang, 2001) covering various threats to health. humans and the environment, including toxicity, physical hazards, global climate change, and the depletion of natural resources. Through the framework of thinking in this concept, everyone, whether researchers, lecturers, teachers, students, laboratory technicians who work in the chemical field, will focus more on a perspective to put environmental and work safety aspects on top priority (Sharma et al., 2008; Collins, 1995).

Given the importance of the concept of green chemistry as an approach to preventing pollution due to chemicals that can damage the environment, this concept needs to be applied in chemistry learning in schools and universities (Andraos & Dicks, 2012; Eilks & Rauch, 2012; Anastas et al. , 2009). The concept of green chemistry must be inspired by teachers and students in order to be able to manage chemicals wisely and wisely, so that they do not damage or pollute the environmental ecosystem. One example of the implementation of this concept in chemistry learning is the activity of managing practicum in a chemistry laboratory. Practicum oriented to the principle of green chemistry is carried out in the form of efforts to reduce, eliminate and replace the use of toxic and hazardous chemicals used in experiments to reduce pollutant levels and waste volume. Chemistry teachers or lecturers as the spearhead in implementing environmentally friendly chemistry learning, need to have knowledge and skills in applying the principles of green chemistry (Eilks & Rauch, 2012).

Complete knowledge of green chemistry will shape the character of students who are more concerned about the environment. It is this attitude and personality that loves the environment that must be instilled in every student as required in the goals of national education (Law Number 20, 2003). Knowledge of how to behave towards chemistry, processes, products, and chemicals which are summarized in the concept of green chemistry is crucial to be understood for every student and therefore becomes important to be integrated in an environmentally friendly chemistry education curriculum (Eilks & Rauch, 2012).

Several studies (Andraos & Dicks, 2012; Eilks & Rauch, 2012; Anastas et al., 2009; Reed & Hutchison, 2000) have been conducted that discuss knowledge of green chemistry in the chemistry education curriculum and its correlation in education. However, the literature study conducted by researchers has not found any detailed assessment instruments that can be used in general to assess the attitudes of prospective chemistry teacher students towards green chemistry. Therefore, it is necessary to develop a valid and reliable assessment instrument to analyze the attitudes of prospective chemistry teacher students towards green chemistry.

▪ METHOD

This study uses a survey method conducted on chemical education students at FKIP, University of Lampung. Survey research design is a procedure in quantitative research in which the researcher conducts a survey of the sample to describe the attitudes, opinions, behaviors or characteristics of the population (Creswell, 2012). The research sample was

158 students who were taken by random sampling technique from the total number of students from the Department of Chemistry Education, FKIP, University of Lampung.

Research Procedures

This research was conducted by following 5 stages of development research design using the ADDIE model. The description of each stage of the research is as follows: (a) Analysis, at this stage an analysis of the needs and initial knowledge of students about green chemistry is carried out, (b) Design, at this stage the instrument is designed based on a literature review about the instrument of student attitudes towards green chemistry, (c) Development, at this stage an initial design (prototype) of the instrument is developed, (d) Implement, at this stage is content validation based on the judgment of 3 experts, revising the content of the assessment instrument based on expert recommendations, implementing the instrument on the research sample, and finally (a) Evaluation where the construct validation of each factor structure in the instrument is carried out based on survey data and evaluates the product of the assessment instrument related to the content and construction of each item.

Instruments

The instrument used in this study was a questionnaire on the attitude scale of prospective chemistry teacher students to green chemistry.

Data Analysis Technique Data

analysis in this study was carried out in several stages including (a) grouping student answers in each item in the instrument and coding according to 5 levels of the Likert scale, (b) determining whether the data obtained were suitable for analysis using the EFA method, through Kaiser–Meyer–Olkin (KMO) adequacy sampling measurement and Bartlett spericity test, (c) Analyzing the validity of the instrument. 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 extracting principal components 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 instrument of student attitudes towards green chemistry developed. Next (d) analyze the reliability of each dimension in the instrument of student attitudes towards green chemistry based on the calculation of the Cronbach alpha coefficient, (e) calculate the average value and standard deviation for each dimension in green chemistry used to describe the level of student mastery of green chemistry (according to perceptions). respectively), (f) analyze the correlation of each item and each dimension of attitude towards green chemistry using the Pearson product moment, (g) model the structural equations and confirm each construct obtained in the EFA analysis using confirmatory factor analysis students.

▪ RESULT AND DISCUSSION

Exploratory Factor Analysis

This study applies exploratory factor analysis to reveal the structural factors formed as the Green Chemistry Attitude Scale (GCAS) instrument and evaluate the attitudes of prospective chemistry teacher students towards the environment. It is generally known that green chemistry itself has 12 main principles, namely (1). Prioritizing efforts to

prevent waste generation rather than dealing with waste generated in the production process; (2) Atomic efficiency; (3) Reducing the use of hazardous and or toxic chemicals; (4) Designing products that are more environmentally friendly; (5) Increasing efforts to use solvents and other chemicals that are not dangerous; (6) Designing efficient energy use; (7) Prioritizing the use of renewable basic materials; (8) Carrying out a relatively shorter synthesis process (avoiding the process of decreasing the synthesis product); (9) Prioritizing catalytic reactions over stoichiometric reactions; (10) Designing products that can be degraded (recyclable); (11) Performing analytical methods on pollution prevention efforts; and (12) Minimize the potential for work accidents. However, to focus and examine more deeply related to student attitudes towards green chemistry, this study will focus on 4 main principles, namely: Prevention, Design for Energy Efficiency (energy efficiency in chemical process design), Safer Solvents and Auxiliaries (use of safe solvents), and Design for Degradation (design of biodegradable chemical processes).

Before further applying the EFA, it must first be known whether the data set from the survey results that have been carried out is suitable to be applied in the EFA analysis and so that the subsequent results can be trusted. In this case, the Kayser-Mayer-Olkin (KMO) test of adequacy and the Bartlett test of sphericity were carried out. KMO is a comparison index of the distance between the correlation coefficient and its partial correlation coefficient. If the sum of the squares of the partial correlation coefficients between all pairs of variables is small when compared to the sum of the squares of the correlation coefficients, it will produce a KMO value close to 1. The KMO value is considered sufficient if it is more than 0.5. While the Bartlett test aims to determine the relationship between variables in multivariate cases. The results showed that the KMO value was 0.880 and the Bartlett test obtained a value of 2 = 836.255, sig = 0.000. These results indicate that the data obtained from the study can be continued and are suitable for EFA analysis.

Table 1. KMO and Bartlett test of sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,880
Bartlett's Test of Sphericity	Approx. Chi-Square	836,255
	df	105
	Sig.	,000

Furthermore, the EFA analysis begins by including all 16 statement items in the instrument as the variables to be analyzed. By using PCA extraction method (eigenvalue > 1) and orthogonal varimax rotation method, the statement items in the instrument are grouped into 4 factors. The results obtained are in accordance with the initial assumption that only 4 principles of green chemistry will be analyzed in detail: factor 1 is prevention; factor 2 is design for energy efficiency (energy efficiency in chemical process design), factor 3 is safer solvent and auxiliaries (use of safe solvents), and factor 4 is design for degradation (design of chemical processes that can be described). In this analysis also, statement item number 3 is not included in the analysis because the extraction coefficient value is low (0.318). The value of loading factor, Cronbach's alpha coefficient, and percent variance explained can be observed in Table 2.

Table 2. Value of loading factor, Cronbach's alpha, and variance per item statements

	Component			
	factor 1 ($\alpha = 0.753$; $s^2 = 10.523\%$)	factor 2 ($\alpha = 0.688$; $s^2 = 13.084\%$)	factor 3 ($\alpha = 0.754$; $s^2 = 18.190\%$)	factor 4 ($\alpha = 0.662$; $s^2 = 20.341\%$)
1. I like to educate people about waste, pollution and environmental problems caused by chemicals				,819
2. I am willing to disseminate information about efforts to prevent waste that is harmful to the environment				,642
4. If possible, chemical compound synthesis should be carried out at room pressure and temperature			,485	
5. Chemical synthesis and practicum must save use electricity			,693	
6. When working in a chemical laboratory, I am willing to limit the use of air conditioners and fans			,859	
7. I feel happy when I save energy			,626	
8. I am willing to turn off lights that I do not use in the laboratory um chemistry			,502	
9. I have to save water when doing chemistry practicum			,573	
10. When I have to decide between buying two chemical solvents, I tend to choose one solvent that does not harm the environment		,615		
11. I prefer to use water as a solvent than other solvents		,751		

12. As much as possible I do not use organic solvents (eg chloroform, acetone, etc.) so as not to harm the environment		,662
13. In my opinion, chemical process modifications should be made to minimize or avoid unnecessary by-products	,595	
14. product chemicals must be designed to be biodegradable	,590	
15. I would like to know more about the recycling process	,805	
16. I am willing to use recycled products (eg recycled paper, glass and cans)	,627	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 11 iterations.		

Based on the data in table 2, it can be observed that the Cronbach alpha coefficients of factors 1, 2, 3, 4 are 0.753; 0.688; 0.754; 0.662 with the overall value or total Cronbach alpha is 0.879. These results indicate that each factor has sufficient reliability (not too good but not too bad) and can still be declared reliable for the next analysis because it is also supported by a large total Cronbach alpha. Besides that, it is known that the total value of variance in the instrument is 62.138% with the largest variance owned by factor 4 (design for degradation) with a variance of 20.341%. Table 2 also shows that the rotated factor loadings of each question item in the attitude of prospective chemistry teachers to the environment range from 0.485 to 0.859. These results state that these items are valid and worthy of inclusion in the instrument to produce good predictions according to the EFA validation criteria suggested by Stevens (2002) where the items that are maintained must have a loading factor > 0.40.

The level of attitude of prospective chemistry teachers towards the environment

The analysis of the level (degree) of chemistry teachers' attitudes towards the environment in this study was based on the method described by Suprapto (2016) through a comparative analysis of the mean and grandmean values. The mean value for each factor that is above the grandmean value is considered a major contributing factor to the attitude of prospective chemistry teachers towards the environment. Based on table 3, information is obtained that only factor 3 (safer solvent and auxiliaries) with M = 4.229; SD = 0.813 and factor 4 (design for degradation) with M = 4.320; SD = 0.820 which has a mean > grandmean. Factor 4 ranks first in terms of its contribution to the overall attitude of prospective chemistry teacher students towards the environment

Table 3. the mean value of each factor, total mean, and standard deviation of

Factor	M	SD	Ranking
Prevention	3,975	0,848	4
Design for energy efficiency	4,056	0,897	3
Safer solvents and Auxiliaries	4,229	0,813	2
Design for degradation	4,320	0,820	1
Total	4,15	0,862	

Interrelationship between structural factors in teacher candidates' attitudes towards the environment

The relationship between structural factors in this study can be explained based on Pearson's product moment analysis. The results of the bivariate correlation analysis in this study are presented in table 4.4. Based on table 4.4, it is known that the correlation coefficient of the four factors studied ranges from 0.395 to 0.648 where each factor is significantly correlated at the 0.01 level. According to Creswell (2012), the correlation coefficient in the range of 0.35 – 0.65 is very useful for limited predictions (useful for limited predictions).

Table 4. relationship between factors based on Pearson correlation analysis

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1	,457**	,395**	,499**
Factor 2	,457**	1	,609**	,601**
Factor 3	,395**	,609**	1	1,648**
Factor 4	,499**	,601**	,648**	.

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

This study aims to develop, validate, and evaluate the attitudes of prospective chemistry teacher students towards the environment. Through a survey study of Chemical Education students at the University of Lampung, the green chemistry attitude scale instrument was developed using exploratory factor analysis. In the early stages of the research, the researcher made a prototype of the instrument to be developed. A total of 16 statement items were made based on the 4 principles of green chemistry developed by Anastas & Werner (1998). For the prototype instrument, content validation was carried out by 3 experts to provide recommendations related to items that must be changed, added or removed. Several expert recommendations were applied as instrument revisions before being distributed to respondents.

The revised instrument was then distributed using the traditional survey method for further analysis of hidden factors that accommodated the items in the instrument. Prior to the factor analysis using EFA, an evaluation of the research data was carried out whether it was suitable for analysis using EFA or not. The results of the study obtained the KMO value of 0.880 and the Bartlett test obtained the value of 2 = 836.255, sig = 0.000. In order for the appropriate data set to be carried out for EFA analysis and the results of the EFA analysis can be accounted for, the KMO test value must be close to 1 and the Bartlett test significance value must be below 0.01. The results of the KMO test and Bartlett's specificity revealed that the data obtained from the study can be continued for EFA analysis and can be accounted.

Furthermore, by using the principal component analysis method with an eigenvalue greater than 1 and the orthogonal rotation method, the statement items are grouped into 4 factors according to the study limitations in this study. The four factors include Prevention (factor 1), Design for Energy Efficiency (factor 2), Safer Solvents & Auxiliaries (factor 3), and Design for Degradation (factor 4). The results of the analysis show that the four factors have a loading factor ranging from 0.485 to 0.859. This result is in accordance with the Stevens (2002) criteria where the items that must be maintained must have a rotated loading factor value of more than 0.40. Besides that, the Cronbach's alpha value for each factor ranges from 0.662 to 0.754 which is in the medium category, but the total Cronbach's alpha for each factor is 0.879 which is in the high category. The results of the loading factor and Cronbach's alpha reveal that each item and factor can be declared constructively valid and reliable. Therefore, the instrument in this study is highly recommended for future related research or for analyzing teacher candidates' attitudes towards the environment. In addition, the largest percentage of variance is owned by factor 4 with a value of 20.341% of the total variance in the instrument 62.138% which indicates that 1/3 of the diversity that arises from student answers comes from their attitudes about chemical waste prevention (prevention). This reveals that students of Chemistry Education at the University of Lampung have different attitudes about preventing chemical waste.

Comparative analysis of the mean and grandmean values revealed that factor 3 (second rank) and factor 4 (first rank) had a larger mean value than the grandmean. This means that in general the research sample tends to have a positive attitude about the importance of recycling or recycling in chemical processes. Besides that, most of the participants agreed that chemical products must be degradable or able to be decomposed naturally. Participants also had a positive attitude towards the use of solvents or solvents in chemical synthesis. They agreed that chemical processes should use water as a solvent, and/or other solvents that are not harmful to the environment.

▪ CONCLUSION

Based on the results of the research that has been obtained, several conclusions can be drawn including: The Green Chemistry Attitude Scale as an instrument for evaluating the attitudes and concerns of prospective chemistry teacher students towards the environment has been successfully developed. The developed instrument has a fairly high construct validity and reliability in terms of the loading factor coefficient and Cronbach's alpha. Furthermore, judging from the analysis of the comparison of the mean and grandmean, most of the samples have the same positive attitude towards the concept of recycle in chemical processes and the use of harmless solvents in chemical synthesis. Finally, Pearson correlation analysis proves that each factor is significantly correlated with each other.

▪ REFERENCES

Anastas, PT, Levy, IJ, & Parent, KE (Eds.). (2009). Green chemistry education: changing the course of chemistry. American Chemical Society.

Anastas, PT, & Kirchhoff, MM (2002). Origins, current status, and future challenges of green chemistry. Accounts of chemical research, 35(9), 686-694.

Andraos, J., & Dicks, AP (2012). Green chemistry teaching in higher education: a review of effective practices. Chemistry Education Research and Practice, 13(2), 69-79.

Clark, JH (1999). Green chemistry: challenges and opportunities. Green chemistry, 1(1), 1-8.

Collins, TJ (1995). Introducing green chemistry in teaching and research. Journal of Chemical Education, 72(11), 965.

Eilks, I., & Rauch, F. (2012). Sustainable development and green chemistry in chemistry education. Chemistry Education Research and Practice, 13(2), 57-58.

Hjeresen, DL, Schutt, DL, & Boese, JM (2000). Green chemistry and education. Journal of Chemical Education, 77(12), 1543.

Sharma, SK, Chaudhary, A., & Singh, RV (2008). Gray chemistry verses green chemistry: challenges and opportunities. Rasayan Journal of Chemistry, 1, 68-92.

Wenxiang, ZHU (2001). Green chemistry and Green chemistry Education [J]. Journal of Chemical Education, 1,000.

Levy, IJ, Haack, JA, Hutchison, JE, & Kirchhoff, MM (2005). Going green: Lecture assignments and lab experiences for the college curriculum. Journal of Chemical Education, 82(7), 974.

Reed, SM, & Hutchison, JE (2000). Green chemistry in the organic teaching laboratory: an environmentally benign synthesis of adipic acid. Journal of Chemical Education, 77(12), 1627.