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# Sustainable environmental education for pro-environmental engineering students: the assessment of a measurement model

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ABSTRACT: The purpose of this study was to test the validity and reliability of a model to measure the level of pro-environmental behaviour and attitudes among engineering students. The study population comprised students of the Faculty of Engineering at Makassar State University, Makassar, Indonesia, totalling 4,164, with purposive sampling involving 215 respondents. The questionnaire consisted of behaviour towards conservation variables and attitude variables including energy conservation, mobility and transportation, waste prevention and recycling. Confirmatory factor analysis (CFA) was used to analyse the collected data. The results obtained from the construct reliability indicate a good level of reliability (CR $\geq$ 0.7), and the average variance extracted (AVE) is $\geq$ 0.5, which means that more than half of the constructs explained the indicators. From the standardised loading factor (SLF) results, four out of 21 indicators with a value of $\geq$ 0.50 were identified, which is smaller than the recommended value ($\geq$ 0.70), but the result can still be considered to have strong enough validation to explain the construct. The results demonstrate that the validity and reliability of the model allow its use as an instrument for a continuous measurement of students' attitudes and behaviour on environmental issues related to their education at the university.

Keywords: Attitude and behaviour towards conservation, confirmatory factor analysis, environmental knowledge, psychometric

## INTRODUCTION

Environmental damage caused by excessive use of natural resources leads to a decrease in environmental quality, which has an impact on increasing air pollution, water contamination, soil contamination, damage to ecosystems, wildlife extinction and increased global warming [1-3].

One of the reasons for this situation is a lack of knowledge and concern for the environment. It may appear that only some individuals, organisations or countries fully express their environmental concerns - there are still many who do not care about environmental problems. The handling of environmental problems is often limited to rhetoric and administration, and it has not resulted in action. The actions carried out are sometimes limited in scope and reduced to ceremonial activities and events.

If this attitude of indifference to environmental issues continues, it will lead to an environmental disaster and over time to a man-induced ecological suicide. Environmental disasters tend to have a huge impact on human attitudes at the time of their happening; however, that impact often fades out with the passage of time. It appears that universal environmental awareness strengthened though environmental education could be the right path to solving environmental problems and preserving nature. Part of that awareness is the development of pro-environmental behaviour and attitude among younger generations that need to care about the environment and take responsibility for future environmental damage [4].

The knowledge gained during learning is crucial to apply to everyday life, and attitude can be understood as a sedentary tendency to react positively or negatively to specific situations, people or goods. In this case, the manifestation of a person's learning behaviour will be marked by a behavioural shift towards an object, value system or events. Several factors affect a person's knowledge, including experience, education, believes, facilities, income and socio-culture. Individuals that have gone through the six levels of learning; namely, remembering, understanding, applying, analysing, evaluating and creating [5], will manifest in their behaviour the learned concepts and values.

Based on the 2018 Environmental Performance Index (EPI) developed by the Yale Centre for Environmental Law and Policy and the Centre for International Earth Science Information Network at Columbia University in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission, Indonesia had a low environmental ranking as it was in 133 position out of 180 countries. The ranking was based on various criteria, such as air quality, protection of general public health, protection of natural resources, exhaust gases, and others [6].

The poor quality of the environment is due to human behaviour, so humans need to embrace pro-environmental behaviour to improve this situation [7]. The conservation and preservation of natural resources or energy is evidence of caring behaviour towards the environment. In addition, the willingness to act in specific ways based on pro-environmental attitudes will result in positive outcomes [8]. Pro-environmental actions are focused on making every effort to save natural resources, use the minimum amount of energy and encourage energy conservation efforts.

Environmental problems are challenging for educators, because of their complexity, and the subjectivity and lack of knowledge about environmental problems among students. Students' perceptions of environmental problems vary, depending on their awareness and understanding of specific environmental conditions. Indonesia, as any other country, needs people that are aware of the environment, especially those who understand ecological principles and apply environmentally-conscious practices. Several studies show that knowledge (objective and subjective) influences how people express their environmentally friendly beliefs and values [9]. Educational institutions have a definite role in shaping student behaviour and attitudes towards the environment, especially in regard to an environmentally friendly lifestyle. A person's understanding of the environment will influence their attitudes and behaviour.

Environmental education carried out at educational institutions is an effort to change the behaviour and attitudes of students by increasing their knowledge, skills and awareness of environmental values and issues to the benefit of future generations [10]. Within the educational system, students have to be involved in maintaining, preserving and solving environmental problems. Therefore, they must be educated to recognise environmental issues, be aware of them, and believe that their attitudes and behaviour will have a positive impact on the environment and their own lives.

## RESEARCH METHOD

### Population and Sampling

The population in this study were students of the Faculty of Engineering at Makassar State University, Makassar, Indonesia. In 2019, there were 4,164 students in the Faculty. For this study, it was imperative to obtain a representative sample for analysis, as the conclusions from the analysis results referred to the whole cohort, and not only to the sample group. It was established that 215 participants comprised a sufficient sample size for the purposive sampling method used in this study. This size follows the recommendation that the number of participants from the studied population should be 5-10 times the number of variables or within the ranges from 100 to 200 participants used in the measurement model [11]. Engineering students active for three years as students in the Faculty comprised the sample group.

Table 1: Demographic information of participants.

| Category | Items | Total | Percentage |
|---|---|---|---|
| Faculty of Engineering | Department of Civil and Planning Engineering Education | 25 | 11.63% |
| | Department of Electronic Engineering Education | 32 | 14.88% |
| | Department of Electrical Engineering Education | 35 | 16.28% |
| | Department of Information and Computer Engineering | 41 | 19.07% |
| | Department of Mechanical Engineering Education | 29 | 13.49% |
| | Department of Automotive Engineering Education | 29 | 13.49% |
| | Department of Agricultural Technology Education | 24 | 11.16% |
| Gender | Male | 187 | 86.98% |
| | Female | 28 | 13.02% |

### Data Analysis

Confirmatory factor analysis (CFA), which is part of structural equation modelling (SEM) was used to analyse the collected data. CFA is an analytical tool used to test a measurement model following the study's objectives. The measurement model is often called the *outer model*, showing how the manifest/observed indicators represent latent constructs; namely, by testing the validity and reliability of these latent constructs. With this analysis tool, it can be found out whether the existing indicators can explain a given construct. CFA is a method with a predetermined model, where the number of latent variables is determined in advance. Therefore, parameters that form variables not directly measurable based on theoretical foundations need to be identified, and it may happen that an indicator cannot adequately explain the latent construct [12]. For the confirmatory factor analysis of data in this study, the IBM AMOS 22 program was used. The AMOS program is currently one of the most sophisticated regression programs for processing multi-dimensional and tiered models.

### Instruments and Procedures

The psychological scale or research instrument is a tool for researchers to collect data. The quality of the instrument will determine the quality of the data collected. The instrument is used to obtain data from the field or sources to be researched.

In this study, data processing and analysis were conducted quantitatively, with the data obtained by distributing questionnaires and drawing conclusions from the respondents' answers. The questionnaire consisted of pro-environmental behaviour variables and pro-environmental attitude variables including energy conservation, mobility and transportation, waste prevention and recycling.

Table 2: Questionnaire statements and the corresponding item codes.

| No. | Statements | Item |
|---|---|---|
| 1 | I wash my clothes after a day of use. | EC1 |
| 2 | I would turn off the light if I were the last person to leave the room. | EC2 |
| 3 | I leave the electrical appliances on. | EC3 |
| 4 | When staying at hotels, I change my towels every day. | EC4 |
| 5 | I ride a bicycle or walk to school or do other activities. | MT1 |
| 6 | I am actively using a private motorised vehicle (car/motorbike). | MT2 |
| 7 | I walk or ride my bicycle to get to a nearby place (a 15-minute ride). | MT3 |
| 8 | If forced, I use public transportation (bus, busway, taxi or train) for my activities. | MT4 |
| 9 | I buy canned drinks. | WP1 |
| 10 | I accept the plastic bag the cashier offered me. | WP2 |
| 11 | When I go on a trip, I bring a single-use drink. | WP3 |
| 12 | At parties, we use plastic cutlery and paper cups. | WP4 |
| 13 | I collect and recycle used paper. | RC1 |
| 14 | I throw empty glass bottles in the recycling bin. | RC2 |
| 15 | I separate the trash by type. | RC3 |
| 16 | I keep the gift wrap. | RC4 |
| 17 | I try to persuade my parents and family to buy an energy-efficient car. | BC1 |
| 18 | I donated some money to an environmental organisation. | BC2 |
| 19 | I read books and publications about environmental problems. | BC3 |
| 20 | I study environmental problems through the media. | BC4 |
| 21 | When shopping, I prefer products with environmentally friendly labels. | BC5 |

The measurement scale suitable for a survey with quantitative data is the Likert scale. The five-point Likert scale used in this study included the following possible responses: 5 - very often; 4 - often; 3 - sometimes; 2 - rarely; and 1 - never. A questionnaire including the statements was distributed to the students selected through purposive sampling. The measurement model applied in this study can be found in the Appendix at the end of the article.

## RESULTS AND DISCUSSION

### Goodness of Fit (GOF)

The model suitability and cut-off value tested for various goodness of fit criteria at this stage. The minimum parameters recommended by Schumacker and Lomax [13], as a requirement for the goodness of fit (GOF) criteria, are the root mean squared error of approximation (RMSEA), goodness of fit indices (GFI), comparative fit index (CFI), and the normed fit index (NFI) that must meet a threshold value. The results can be seen in Table 3:

Table 3: Goodness of fit (GOF) criteria.

| Parameter | Cut-off value | Value |
|---|---|---|
| Goodness of fit indices (GFI) | > 0.900 | 0.984 |
| Root mean squared error of approximation (RMSEA) | < 0.080 | 0.001 |
| Comparative fit index (CFI) | > 0.900 | 1.002 |
| Normed fit index (NFI) | > 0.500 | 0.815 |

The goodness of fit (GOF) measurement results in Table 3 show that all the required criteria are below the threshold value, which means that the development of the proposed measurement model could continue.

### Convergent Validity

In order to fulfil the assumption of convergent validity, each construct (indicator) had to obtain a critical ratio (CR) value greater than twice the standard error (SE) value or with a probability value of the indicator smaller than 0.05.

Table 4 shows that the assumption of convergent validity in the measurement model has been fulfilled, as seen from the probability value obtained ≥ 0.05.

Construct measurement is done indirectly through its indicators. Thus, indicators with high loading factors have a higher contribution to explaining the latent construct. Conversely, indicators with low loading factors have a poorer contribution in this respect.

Table 4: Standardised loading factor (SLF).

| Construct latent | Indicators | Estimate | SE | CR | Probab. | Loading factor |
|---|---|---|---|---|---|---|
| Energy conservation | Item EC1 | 0.754 | 0.228 | 3.307 | 0.000 | 0.871 |
| | Item EC2 | 0.852 | 0.324 | 2.630 | 0.000 | 0.798 |
| | Item EC3 | 0.843 | 0.244 | 3.455 | 0.000 | 0.753 |
| | Item EC4 | 0.523 | 0.143 | 3.657 | 0.000 | 0.683 |
| Mobility and transportation | Item MT1 | 0.525 | 0.215 | 2.442 | 0.008 | 0.768 |
| | Item MT2 | 0.938 | 0.381 | 2.462 | 0.003 | 0.675 |
| | Item MT3 | 0.462 | 0.162 | 2.852 | 0.000 | 0.831 |
| | Item MT4 | 0.763 | 0.155 | 4.923 | 0.000 | 0.785 |
| Waste prevention | Item WP1 | 0.534 | 0.181 | 2.950 | 0.000 | 0.627 |
| | Item WP2 | 0.738 | 0.133 | 5.549 | 0.000 | 0.824 |
| | Item WP3 | 0.583 | 0.221 | 2.638 | 0.000 | 0.881 |
| | Item WP4 | 0.573 | 0.235 | 2.438 | 0.011 | 0.745 |
| Recycling | Item RC1 | 0.752 | 0.252 | 2.984 | 0.000 | 0.717 |
| | Item RC2 | 0.717 | 0.271 | 2.646 | 0.012 | 0.792 |
| | Item RC3 | 0.665 | 0.243 | 2.737 | 0.000 | 0.655 |
| | Item RC4 | 0.686 | 0.213 | 3.221 | 0.000 | 0.775 |
| Behaviour towards conservation | Item BC1 | 0.678 | 0.231 | 2.935 | 0.000 | 0.788 |
| | Item BC2 | 0.881 | 0.357 | 2.468 | 0.002 | 0.818 |
| | Item BC3 | 0.686 | 0.281 | 2.441 | 0.006 | 0.722 |
| | Item BC4 | 0.754 | 0.228 | 3.307 | 0.000 | 0.852 |
| | Item BC5 | 0.789 | 0.254 | 3.106 | 0.000 | 0.765 |

The observed indicator or variable has to have a good convergent validity of the loading factor value or the standardised loading factor (SLF) value is significant. However, significant SLF values often have a weak correlation. Therefore, the rule of thumb is that SLF values of ≥ 0.50 are acceptable, and it is recommended that they are ≥ 0.70 [11].

The analysis results show four standardised loading factor values lower than 0.70; namely, the EC4, MT2, WP1 and RC3 items. Nevertheless, the obtained value of ≥ 0.50 can still be considered to have sufficiently strong validation to explain the latent constructs. Other references state that the weakest acceptable loading factor is 0.40 [14].

Construct reliability (CR) and average variance extracted (AVE) parameters are also indicators of convergent validity. For example, the construct reliability (CR) ≥ 0.7 indicates good reliability, but the reliability value of 0.6-0.7 is still acceptable provided that the validity of the indicators in the model is good. When the acceptable AVE value is ≥ 0.5, it demonstrates that more than half of the constructs explain the indicator [15]. The calculations shown in Table 5 indicate the CR and AVE values in each study construct required to obtain acceptable reliability results.

Table 5: Convergent validity criteria.

| Construct latent | Construct reliability | Average variance extracted (AVE) |
|---|---|---|
| Energy conservation | 0.776 | 0.915 |
| Mobility and transportation | 0.765 | 0.909 |
| Waste prevention | 0.769 | 0.911 |
| Recycling | 0.761 | 0.903 |
| Behaviour towards conservation | 0.788 | 0.936 |

From the unidimensional testing process of the measurement model and the calculation of the validity and reliability of pro-environmental education measuring tools based on the confirmatory factor analysis (CFA) method, the results show that the measurement model can be accepted according to the test criteria. Evaluation of measurement models focuses on the relationship between dimensions and constituent items. The validity criterion is also helpful in checking

the accuracy of questionnaires, while the consistency of the measurement done by testing the reliability means that the measuring instrument can be used repeatedly.

According to the participants' learning schedule, the difference in data collection time in class also affects the study results. Therefore, the validity and reliability of measuring instruments have different values. The collection of data in the morning, when the condition and attention of the participants doing the test are good and the overall atmosphere is conducive, will be different to the data collection carried out during the day when the participants' attention and condition begin to decline. The number of study participants impacts on the results. As their number increases, so does the validity and reliability of the measuring instrument. Therefore, the measurement model tested with more participants will become more fit.

Various factors can influence pro-environmental behaviour, including situational engagement that positively impacts pro-environmental behaviour. This positive relationship arises from the tendency to respect one's own place of residence and not destroying the environment in which one lives [16].

In addition, individuals with a positive attitude find it easier to be motivated to expand their knowledge of current environmental conditions and problems, directly encouraging positive behaviour towards environmental sustainability. However, education and environmental knowledge are essential factors in increasing environmental awareness. For example, when well-educated individuals become aware of environmental problems, their behaviour directly demonstrates that they care about the environment by saving energy [17].

Having a positive attitude towards the environment does not necessarily mean caring for the environment, as attention to the environment is also quite important in most cases. In general, attitudes towards the environment express one's beliefs and values [18] and those attitudes need to be considered in the context of the relationship between humans and the environment. The attitude can be influenced by several factors, including perception of behaviour. At the same time, the influence of behaviour on individuals also depends on the attitudes gained from knowledge about the environment.

To effectively encourage pro-environmental behaviour, it is necessary to identify the type of knowledge needed, as well as an efficient information dissemination strategy to promote pro-environmental education. The knowledge about sustainable development is essential because it results from green behaviour. Therefore, green behaviour can also be referred to as pro-environmental behaviour.

## CONCLUSIONS

The need for measuring tools (instruments) for pro-environmental attitudes and behaviour is expected to increase and expand, considering the environmental damage increasingly caused by humans. The proper measuring instrument should be of high quality and should reflect the current conditions.

The instrument described in this article has been designed to measure the pro-environmental attitudes and behaviour of university students. The designed model can be expended into a more complex structural model to test the causality relationship between the variables of the developed pro-environmental behaviour and attitudes.

The testing of the measurement model can reveal the closeness of the relationship between the indicator and its construct. If the measurement model is considered valid, the test could continue on the structural model to obtain a number of correlations that show the relationship between the constructs. After the model is complete and the relations identified, the stage is continued by testing the measurement model and the structural model.

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BIOGRAPHIES

Muhammad Ichsan Ali is Vice-Rector for Planning and Co-operation of Makassar State University, Indonesia. He has worked as a lecturer since 1998 in the Department of Civil Engineering Education and Planning. He completed a Bachelor's degree in civil engineering in 1990 at Hasanuddin University in Indonesia, and in 2005, earned a Master's degree in civil engineering at the same university. He earned a Doctorate in the Department of Population and Environmental Education in the Postgraduate Programme of Makassar State University, Indonesia. Currently, he is active in several professional associations, including the National Association of Indonesian Consultants (NAIC), the Indonesian Chamber of Commerce and Industry (ICCI), and the Indonesian Road Development Association (IRDA).

Sidrah Afriani Rachman is a lecturer in the Faculty of Education at Makassar State University, Indonesia. She received a research grant from the Indonesia Managing Higher Education for Relevance and Efficient Projects (1-MHERE), and a Bachelor's degree in education at Makassar State University in 2010. She earned her Master's degree in education at Makassar State University in 2013, and has recently been awarded a Fulbright PhD scholarship at Ohio State University in the United States of America. In 2016, she participated in the Pre-post Teacher Priority Training in Reading and Writing on the USAID Programme. She is currently conducting environmental education programmes aimed at the elementary school level through camping activities and social services named the Encyclopaedia Meeting Club.

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APPENDIX

Measurement Model for Pro-environmental Attitudes and Behaviour