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Action-oriented learning to promote electrical energy savings

Siti Sendari†, Waras Kamdi†, Yuni Rahmawati†, Indriyani Rachman‡ & Toru Matsumoto‡

State University of Malang, Malang, Indonesia†
University of Kitakyushu, Kitakyushu, Japan‡

ABSTRACT: The aim of this article is to present a programme on action-oriented learning of energy education (EE) to promote students' energy awareness of electrical power saving. The EE has four components: technology, academic, community and government. This research was the result of collaboration between two universities, i.e. the State University of Malang (UM), Malang, Indonesia, and the University of Kitakyushu (UK), Kitakyushu, Japan. In Malang, behaviour was studied informed by the situation in Kitakyushu, Japan. This energy education study programme could be used to improve the awareness of electrical energy saving.

INTRODUCTION

Energy, especially electrical is used in industry, transportation, public services and residential dwellings. Total public services and residential energy consumption in Indonesia was 38% of the total in 1973, rising to 49% in 2015 [1]. Indonesia produces 2.7% of the world fossil fuel-generated electricity. The Indonesian government has proposed a blueprint of national energy management to reduce the 49% to 41% of the total energy supply consumption by 2025 [2].

Implementing low-energy light bulbs [3] and keeping appliances in standby mode are the means of saving electricity [4]. The efforts are not effective if they are not supported by users' behaviour. Users' energy awareness and behaviour can change consumption behaviour. Energy education has improved the energy awareness of Brazilian, Spanish, Belgian and Italian citizens [5]. Therefore, a study of behaviour on energy consumption in Indonesia is appropriate. Explored in this article is an action-oriented learning method for energy education (EE), which aims to promote students' energy awareness. Adopted in this study was a Japanese model and its implementation for a group of university students and a community in Malang, Indonesia. The individuals' behaviour was observed and analysed to discover the efficiency of EE in improving the people's awareness of energy consumption.

DEVELOPING ENERGY EDUCATION

A model of EE was integrated into the engineering curricula in the form of an energy minor curriculum [6]. This has been studied in electrical engineering vocational schools [7], computer engineering [8] and the pre-university of power lessons [9]. The energy education development steps are to:

1. develop an energy minor curriculum;
2. develop a senior undergraduate engineering course;
3. form a student energy club;
4. deliver a 10-week summer research programme for undergraduate students [10].

These steps were delivered by a team of interdisciplinary staff and a scientist. Evaluations were used to determine the course efficiency in boosting the students' major and technical skills. This confirmed that it is possible to integrate electrical and environmental engineering in the campus, so as to face the energy issues.

Peer Learning

A collaborative learning method was adopted so as to develop EE. This method uses a peer learning strategy [11] and can be implemented in schools and universities. Furthermore, it can also be implemented in the community, such as by voluntary organisations and after-school clubs [12].

As said above, peer learning was the strategy, since EE involves faculty members, students and the community. Matters addressed included the need to:

- determine participants' knowledge level (potential trainers);
- train the trainers;
- develop a help technique;
- develop material for training (first for staff, then for helpers, and then for the helped);
- monitor for quality assurance;
- assess the product and process (evaluation and feedback).

Kitakyushu as a Role Model for Energy Education

Kitakyushu is one of the major industrial cities in Japan, located on the island of Kyushu. In the 1960s, the city had severe air, water and land pollution due to industrial activities. This motivated the citizens, government and industry to tackle the environmental problems. Kitakyushu was then transformed into an eco-city with sustainable development to preserve the city for future generations [13].

This involved a number of educational facilities and activities. Public eco-education was promoted by Eco Club activities for children using citizen volunteers. The Environment Museum and other eco-education facilities are much visited. The implementation of Japanese government rules is monitored and community facilities were built without industry funds being required.

In Kitakyushu, electrical energy education is embedded in environmental education. It is supported by the city's environmental protection and educational facilities. Citizens are urged to use energy appropriately promoted by learning videos, interactive games, educational books and exhibitions.

Power and Energy Saving

Power and energy saving is related to energy efficiency. In Indonesia, 41% of energy is consumed by the residential sector, followed by industry, 34%, and the commercial sector, 18%. It is important for the future to control energy as stated in the (Indonesian) presidential instruction no. 13, year 2011 that energy efficiency requires designing systems better able to manage energy and teaching society to use less energy [14].

Power and energy saving is considered an important part of energy education in Indonesia due to the increased cost of fossil-based energy production. Citizens' electricity bills have increased, and hence awareness of the use of power and energy should be introduced into energy education.

RESEARCH METHOD

For the research carried out, the authors drew on the energy education of the State University of Malang (UM). The EE components are shown in Figure 1:

- The technology of energy systems; how the systems work and their impact on the environment.
- Behavioural awareness; educate students to save energy and be aware of the environment.
- Policy/rules to enhance EE.

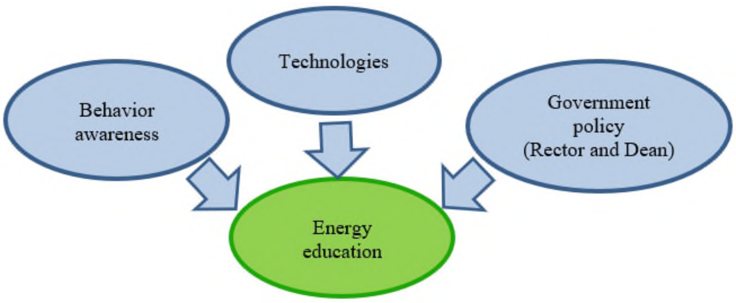

Figure 1: EE components.

Behavioural Awareness in Kitakyushu, Japan

Energy education behaviour awareness in Kitakyushu, Japan, is shown in Table 1, based on information from the University of Kitakyushu (UK). This is from a study of the *Urban Environmental Management of Indonesian Cities Considering the Applicability of the Kitakyushu Model of a Japanese Advanced Eco-model City*. The curricula of vocational schools and government rules were studied.

Table 1: EE activities in Kitakyushu.

No.	Place	Observation result
1.	a. Fukuoka Prefecture; Kokura Technical High School	Embedded EE in the curriculum of vocational high schools
	b. Department of Electrical and Electronic Engineering Kitakyushu, National College of Technology	Embedded EE in the curriculum of vocational higher education supported by facilities for EE
2.	Waste incinerator plant in Shinmoji	Media: magazines, books, brochures and videos of generating energy from community waste
	Eco-town centre	Media: energy generation and reusability
	Sewage treatment plant	Media: water treatment, energy production and usage
3.	Government of Kitakyushu, Environmental Bureau	Rules: environment, including energy and education

Baseline Energy Education

The baseline of EE was determined by research involving department and student officials, class groups and students in the 2017/18 academic year in the Department of Electrical Engineering, Faculty of Engineering, UM. The research was in three stages:

1. Observation stage: to observe students' awareness-behaviour in using electricity, as well as their knowledge when using electrical equipment.
2. Course stage: to design and implement a peer-learning short course for students related to electricity reduction. The comprehension of and willingness to realise EE to support energy saving was observed.
3. Implementation stage: to introduce EE to communities based on students' experiences during the short course.

The proposed learning model for energy education is shown in Figure 2. To support the research, some media and instruments were developed: for observation; for a short course module; for a trainer for energy systems; saving energy instruments; and instruments to realise EE.

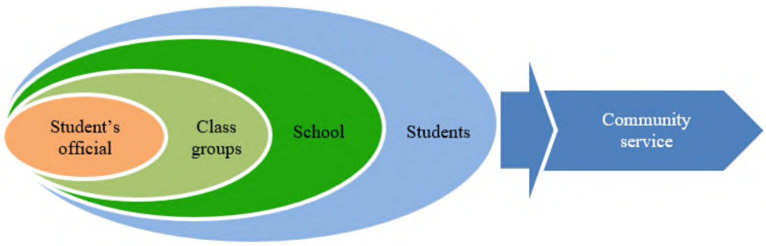

Figure 2: Model for energy education.

There were three short courses modules. The first module was used by students and the community. The aim of it was to teach how to calculate and reduce energy costs by saving electricity. Another two modules enabled the teaching of students on how to develop alternative energy or renewable energy (e.g. biomass and solar cells). Thus, the modules are labelled as follows:

1. Energy saving;
2. Biomass energy systems;
3. Solar cell systems.

As shown in Table 2, the subjects of this research were from the UM Department of Electrical Engineering, and households in the community.

Table 2: Subjects of a survey of awareness behaviour.

No.	Object	Number
1.	Student official	20
2.	Student group and new students	30
3.	Community	200

An instrument was developed to survey energy use [15]. This involved a survey design, question development and instrument validation. It was developed to determine the behaviour and acquaintance of students and the community related to electricity usage. The indicators of this survey are outlined in Table 3. The questions were accompanied by pictures to make the survey understandable for all the community.

Table 3: Indicators and questions for electrical power usage.

No.	Indicator	No. question	Question
1.	Electrical power usage by household (I1)*	Q_1	How much electrical power is used by your house?
		Q_4	Do you know the electrical power needs of your electrical equipment?
2.	Kinds of electrical equipment (I2)	Q_2	What electrical equipment do you have?
3.	Usage of electrical equipment (I3)	Q_3	How long do you use electrical equipment every day?
4.	Calculating the cost of electricity (I4)	Q_5	How much do you spend on electricity every month?
		Q_6	Do you know the base cost of electrical power used by your house?

*I*n* = (Indicator *n*)

RESULTS AND DISCUSSION

Electrical Power Used by the Household

The first step in the baseline of energy awareness was to survey the users about electrical power used by households. The most used was 900 volt-amperes (VA), followed by 450 VA, 1,300 VA and 2,200 VA in that order. Subsidised electrical power was used by 68% of users. The survey showed that 19% of users do not know that the government wants to reduce the number of subsidised users. Hence, energy education is needed to improve the awareness of users in reducing the impact of the cost of electrical power.

Electrical Equipment in Use

Most users use electrical power for lighting (28%), ironing clothes (10%), rice cooking (9%), watching television (8%) and pumping water (7%). Few users use game machines, sewing machines or audio systems.

Usage of Electrical Equipment

The frequency of use of electrical equipment was classified as follows:

1. *Always* means the equipment is used every day;
2. *Seldom* means the equipment is used once every 2 to 4 days;
3. *Rare* means the equipment is not used more than once every 4 days.

Considering the indicators of I2 and I3 from Table 3, frequency of the use of equipment is summarised in Table 4. It can be seen that lights, ironing, rice cooker, television and water pump are used daily.

Table 4: The use frequency of electrical equipment.

No.	Equipment	Frequency		
		Always	Seldom	Rare
1.	Light	74	13	10
2.	Ironing	10	46	44
3.	Rice cooker	74	17	9
4.	Television	66	20	14
5.	Water pump	57	25	18

The Cost of Electricity

It was found that 75% of users do not know the level of consumption of electrical power by their equipment. Power can be reduced by using low power equipment or settings; this requires a change of users' behaviour to save energy. Electrical power consumption starts when the equipment is activated. Hence, the objective of EE in the first year was to educate the community to be aware of electrical power consumption and its cost.

Saving Energy

A short course was designed and implemented to educate students about the need to reduce electricity usage and to calculate the effect. The course consisted of:

- the home electrical power meter;
- electrical consumption per day;
- planning to reduce electrical power consumption;
- benefits of reducing electrical power consumption.

A worksheet for saving energy was developed and validated by experts. Since the users were university students and members of the community with various education levels, ages and gender, the design of the material was to be user-friendly. The appearance of the material is shown in Figure 3.

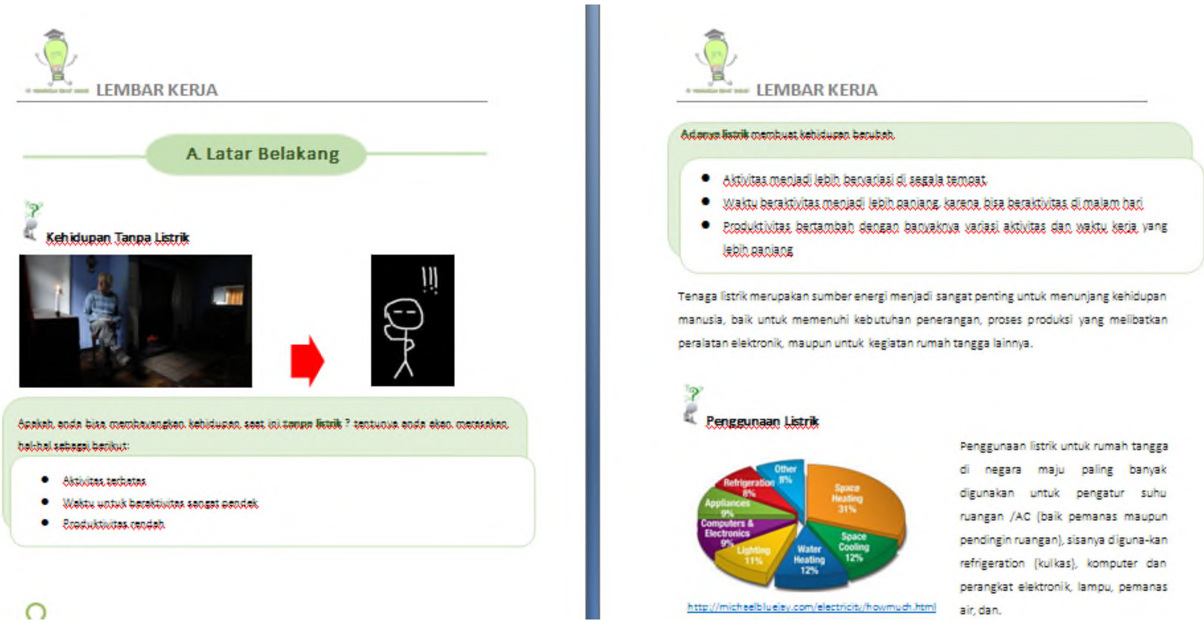

Figure 3: Material for the energy education module.

The module was validated by material and media experts. The validation of the material expert was provided by four indicators:

1. Ease of use (without needing a tutor).
2. Suitability (easy to understand its purpose related to the consumption of energy).
3. Explication (clarity).
4. Completeness (full details of household energy use).

The material expert concluded that the module was valid for the intended users. The evaluation is shown in Table 5.

Table 5: Validation result - material expert.

No.	Indicator	∑ Item	Sum of value (∑xi)	Max ∑xi	% Validation
1.	Ease of use	4	15	16	93.75
2.	Suitability	6	22	24	91.67
3.	Explication	4	14	16	87.50
4.	Completeness	8	29	32	90.63
	Average				91%

The media validation had five indicators:

1. Effectiveness;
2. Ease of use;
3. Suitability;
4. Completeness;
5. Communicativeness.

As seen from Table 6, the media expert concluded that the material was valid.

Finally, in the implementation stage the module was rolled out to communities to spread EE knowledge into the communities. The students help the community to learn the positive effects of electricity savings based on their own experience during the short course.

In the implementation two problems arose:

1. The module was developed as a means to teach energy-saving behaviour through checking the daily usage of electricity. However, this is difficult to do, because many users could not check daily usage. Hence, changing behaviour will be difficult in the short term.
2. The user can restrict the use of home appliances so as to reduce electrical power consumption. However, this is inconvenient, because some home appliances have to be switched off.

Table 6: Validation result - media expert.

No.	Indicator	∑ Item	Sum of value (∑xi)	Max ∑xi	% Validation
1.	Effectiveness	3	11	12	91.67
2.	Ease of use	4	14	16	87.50
3.	Suitability	8	30	32	93.75
4.	Completeness	11	40	44	90.91
5.	Communicativeness	10	37	40	92.50
	Average				91%

CONCLUSIONS

The implementation of EE may increase the awareness of citizens in managing the use of electrical equipment. The attitude towards energy utilisation needs to be changed, to reduce the cost of energy consumption. The energy education model discussed here could be applied to student groups and communities, so as to promote electrical energy savings.

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