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RESEARCH PAPER

An Exploratory Study on Green Chemistry Practices and Experiments in Malaysian Secondary Schools

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Abstract

Although green chemistry had been promoted since 1980s, it is still quite unknown in Malaysia even among chemistry teachers and students. Hence, the success of environmental sustainability education would be hard to achieve if chemistry teachers did not have adequate competency and skills to cultivate students' green chemistry awareness and practices. This study investigated Malaysian chemistry teachers' understanding, awareness and practices on green chemistry; and the impact of student-initiated green chemistry experiments on their practices of environmental sustainability; and on their achievement in the topic of electrochemistry. The survey involved 269 secondary school teachers, and the quasi-experimental study involved 77 secondary school chemistry students (n = 37 in control and n = 40 in treatment groups). A set of questionnaires for the teachers, and a set of tests for the students were employed in the study. Data was analysed using descriptive and inferential statistical techniques. Analysis of the survey found the level of teachers' understanding of green chemistry was at a moderate level, their awareness on the importance of green chemistry was high while the level of their green chemistry practice was moderate. The quasi-experimental results revealed no significant difference in the achievement between students undergoing traditional chemistry experiments and the green chemistry experiments. Nevertheless, students participated in designing green chemistry experiments were found to have higher level of green chemistry awareness compared to the control group. This study recommends that teachers should empower students with suitable mechanisms to address sustainable environment issues in classroom or laboratory instruction to promote sustainable practices among school community.

Keywords: Green chemistry experiment; Student-initiated experiment; Green chemistry practices; Green chemistry awareness

INTRODUCTION

In 1982, the Ministry of Education Malaysia (MOE) introduced Environmental Education (EE) in 305 pilot primary schools and it was fully implemented in 1983 (Harliza, 2017). This Environmental Education is the manifestation of the Stockhlom Conference in 1972, the Belgrade Charter, 1975 and the Tbilisi Conference in 1977. In 1988, the Curriculum Development Centre

(CDC) of MOE published the *Guidebook for Environmental Education Teachers* for primary and secondary schools. The guidebook was designed to facilitate teachers in embedding EE in their classroom instruction, to promote knowledge, understanding and awareness of nature and the environment (Ministry of Education Malaysia, 1998).

The Cabinet Committee was then established in 1974 to review the National Education Policy aimed at improving its implementation so that the goal of creating a united, disciplined society and meeting the needs of the people trained for national development can be achieved (Ministry of Education Malaysia, 2016). One aspect of cross-curricular elements maintained in curriculum standards is the element of environmental sustainability; which play an important role to expose students to face the global world and become an efficient global player (Ministry of Education Malaysia, 2016). According to Harliza (2017), the government introduced Environmental Education (EE) as a subject in the education system at secondary school and tertiary level in 2019 to form good interaction of community members, especially the younger generation, with the environment. Nurul Hidayah, Haryati & Seow (2013) stated educational institutions are the main channels of environmental education. Therefore, students in schools should be directly involved in environmental sustainability efforts (Hanifah et al., 2017; Zyadin et. al., 2012).

After the 7th Malaysia Plan (in 1996), EE was modified to be more robust and given a new look with the application of cross-curricular elements involving formal and informal education (Teacher Education Division, 1997). Elements of Environmental Education are integrated in subjects such as Moral Education, Geography, Language, Islamic Religious Education, and Science. The main objectives of the integration are to cultivate good values for the environment among school community, increase school awareness on the importance of environment conservation and preservation, enhance the implementation of more environmentally friendly programs, enhance cooperation between schools and communities in environmental education programs and create conducive school atmosphere to promote sustainable living practices among school community.

The introduction of EE as a special subject was perceived that it could interfere with the existing curriculum which is considered too heavy for school children (Hasan & Ismail, 2011). Hence, the application of EE in informal education could also be seen through the extra-curricular activities of clubs and associations such as the Nature Lovers Clubs, Recycling Clubs, 5S Clubs, 3K Projects, and environmentally-related visits organized by schools. However, a study conducted by Abdul & Aziah (2007), showed teachers rarely integrate Sustainable Development Education (SDE) in teaching and learning due to lack of knowledge and pedagogical skills. According to Arba'at et. al. (2010), teachers perceived environmental education is the most difficult to teach.

Green chemistry was first introduced in the early 1990s by Paul Anastas and John Warner (Anastas & Eghbali, 2010). Green chemistry is a method of avoiding the use and production of chemicals that have harmful effects on the environment as well as human health, which is also an approach in designing methods to inhibit the production of these substances (Tugce et al., 2017). Green chemistry emphasizes the process of preventing pollution and not cleaning the environment (Anastas & Eghbali, 2010). Green chemistry is one of the important and appropriate methods in ensuring environmental sustainability (Karpudewan et al., 2009). The implementation of green chemistry in schools, especially through practical activities in the laboratory might increase the awareness and practice of chemistry students in improving environmental sustainability (Abdull Patah et al., 2015). The use of safer alternative ingredients in green chemistry indirectly lowers the risk of harm to students and teachers (Haack & Hutchison, 2016). Furthermore, through green

chemistry, solid waste in schools could be better managed as a result of awareness of environmental sustainability (Karpudewan, Ismail & Mohamed, 2011).

The present chemistry education in Malaysia is seen to have limited influence on the pro-environmental practices. Education should not only focus on knowledge but it should be able to influence students in making decisions related to the environment (Taylor et al., 2003). Therefore, changes in the approach to implement environmental education need to be implemented to produce individuals who have a more responsible attitude towards the environment.

In schools, for example, the understandings of school administrators may not be the same as the understandings of ordinary teachers and students. Solid domestic waste management in schools would be more effective if there is strong environmental awareness and knowledge of sustainable practices among school students and teachers. Thus, green chemistry practices need to be promoted to facilitate effective and safe solid and chemical waste management in schools.

The main problems in environmental issues are human ignorance of ecological concepts and processes, environmental insensitivity and failure to act positively on these issues (Bosek, 2014). Environmental awareness in Malaysia is still in its infancy and it is found that the education system in Malaysia has not yet fully succeeded in creating students who are responsible for the environment (Aminrad et al., 2013). The Malaysian Department of Environment (DOE) study revealed 70 percent of the people in the country do not have adequate awareness of environmental issues and another 30 percent do not know the measures to prevent it even though they are aware of the environmental issues. Although in 1983, the implementation of EE across the curriculum has been implemented in all primary schools, until now, the success of EE implementation is still not evident because less emphasis is given to the application of noble values, decision making, and problem-solving skills related to environment sustainability (Aminrad et al., 2013).

Apart from the lack of emphasis on EE, the application of green chemistry could not be well presented due to the poor teaching methods of teachers. Teachers are still found to use whiteboards and give many lectures where students are bribed with facts without understanding. Teachers should wisely play a role in diversifying teaching methods to attract students to learn and enhance and encourage students to apply what they learnt in daily lives. Students should also be actively involved in learning. However, students are not given the opportunity to be actively involved in planning practical activities. Among the reasons why teachers do not actively carry out practical activities and only conduct practical demonstrations is due to poor state of the school laboratory (Alexiou et al., 2005). Therefore, with the exposure of green chemical activities, teachers can plan practical activities in the school by using materials from natural sources and suitable recycled materials to be replaced with chemicals in the practical to be carried out.

Sustainable development is an effort of a group of people to maintain the well-being of the physical environment so that it is always in good condition and able to meet the needs of life (Zamhari & Perumal, 2016). An effective way to increase awareness for the environment in schools is to practice green practices and implementation of curriculum activities that involve students directly (Hasan et al., 2013). According to Taha et al. (2019) teachers must have adequate competency and skills to cultivate students' awareness and practices in environmental sustainability.

Green chemistry is also known as sustainable chemistry which is a form of chemistry designed to prevent pollution (Karpudewan et al., 2016). The green chemistry approach has begun to be recognized and applied in the teaching and learning of chemistry (Karpudewan et al., 2012). In addition to the basic topics taught in the lesson, the concept of environmental and sustainable development is also introduced through green chemistry (Karpudewan et al., 2011). The level

green chemistry awareness in Malaysia is still very low (Yaacob et al., 2003). Teachers may utilise green chemistry experiments by modifying material used and chemical reduction to encourage more sustainable use. According to Mohd Nizar et al., (2019), sustainable use includes using goods and services in a way that minimizes the use of natural resources and chemicals and reduces chemical waste. By designing green chemistry experiments, students are exposed to alternative materials that can be used to replace commonly used traditional chemicals (Taha et. al., 2019). According to Taha et. al. (2019), through exposure using green chemical practices, students will play an active role in helping to reduce the waste product of harmful chemical reactions and carry out practical activities in safer conditions. Therefore, chemistry is an appropriate branch of education in highlighting issues related to the development of sustainable education (Sjostrom et al., 2015).

Green chemistry is closely linked to sustainable development to conserve environmental balance. Therefore, incorporating the principles of green chemistry in schools, especially in school laboratories, may be able to help increase the awareness and understanding of all members of the school community about the role of green chemistry practices in improving environmental sustainability. Green chemistry is more aimed at preventing pollution and not to 'clean up' the environment after pollution. Furthermore, by reducing energy consumption and using safe and environmentally friendly chemicals, the cost of pollution control and waste processing could be reduced. One example of a green chemistry application is to reduce lead contamination by replacing lead-based paint with less toxic tetraethyl lead as a safer alternative. Now the sale of lead-free fuel has become a common phenomenon in our lives. Another instance is fire and rescue departments nowadays use foam called *Pyrocoll FEF* which is created to extinguish fire more effectively without producing toxic side-products. Thus, it is inevitable for us to employ green chemistry in our lives.

The Malaysian government has introduced *672 Act: Solid Waste Management and Public Cleansing 2007 Act* (Law of Malaysia, 2017) providing new instructions and laws emphasizing solid waste management. Among the things that are very emphasized in the 672 Act are waste reduction, use, material recycling, energy saving, and landfills. The use of new technologies in solid waste treatment methods such as evacuation stations, thermal treatment plants can be used as an alternative to solid waste treatment and leachate methods. Unfortunately, this is not very effective because our society does not take seriously the importance of recycling to support sustainable development in Malaysia. Studies show the level of public knowledge about recycling program is only moderate and they showed negative attitudes towards environmental issues (Ahmad et al., 2011). This would certainly impede Malaysian government's target of 22 percent reduction in solid waste trough recycling (Nursuraya, 2011). This problem could be addressed if the environmental awareness of the community is enhanced. Therefore, environmental education should be applied from the school level to enable every member of the community to practice sustainable practices. The importance of green chemistry should be known to all levels of society so people could inform the public or the industry to reduce pollution and emissions of harmful substances into the environment.

The scope of traditional education has been found to be very limited in influencing the change in attitudes needed to reduce environmental pollution (Taylor et al., 2003). Among the causes of environmental education not achieving the desired goal is that teaching and learning only emphasizes the delivery of information without encouraging more responsible action towards the environment. Changes in the environmental education approaches need to produce more responsible attitude towards the environment among the community (Ko & Lee, 2003). To reduce

the negative impact on the environment, society and the economy, we need to take immediate action to reduce waste, reuse, recycle and improve waste disposal methods in schools and nearby communities (Tetrault & McDonald, 2005).

Chemistry education needs to produce students who are capable of actively participating in society, and making informed decisions that impact both their personal lives and society (Eilks & Rauch, 2012). Chemists must rely upon their ability to analyse outcomes, make decisions and recommend actions which they feel best represent the practice of green chemistry, because it is often difficult to uphold all green chemistry principles of at the same time. Thus, the role of chemistry teachers should be refined to address the current needs of the world, so the future generation would be able inherit a pollution-free and safe environment.

In Malaysia, although the concept of Green Chemistry has been preached for quite some time, it has not been widely used or integrated into the education system in this country. Through the application of green chemistry practices in laboratory activities in schools, it may be possible to apply a combination of subject content and environmental awareness to provide knowledge and understanding of teachers and students on green chemistry practices that can be implemented in teaching and learning activities.

Although studies on the effectiveness of green practices in education are still lacking compared to the policies and strategies planned since 1986 when environmental education was introduced, Mohd Akashah et al. (2019) reported that green chemistry experiments could improve student understanding of science through experiences in daily lives. Although the current trend of the application of environmental education has changed, but the overall level of environmentally sustainable practices is still at a moderate level (Auwalu, 2015; Hanifah et al., 2015).

Implementation of green chemistry in the curriculum will gain a great success if and only if the teachers, the knowledge conveyor, are armed with green chemistry knowledge and ready to inculcate green chemistry among the students both in the laboratory activities and chemistry classroom instruction (Taha et. al., 2019). Hence, to play an important role as environment sustainability educationist, chemistry teachers need to disseminate effective green practices to their students. Since the nature of chemistry lessons is very unattractive to students, teachers need to manipulate investigative and research-like approaches to trigger and enhance students' awareness of the environment. Based on what has been stated above, and students as the major player of the project; the objectives of this study were formulated as follows: (i) to identify Malaysian chemistry teachers' level of knowledge, awareness and practices on green chemistry practices, (ii) to identify differences in students' achievement in the topic of Electrolysis between students who did the conventional chemistry experiments from the textbook with those who developed their own green chemistry experiments, and (iii) to identify differences in students' awareness of green chemistry between students who did the conventional chemistry experiments from the textbook with those who developed their own green chemistry experiments in Electrochemistry.

METHODS

Research design

This research combines a survey, and an experimental quasi research. The survey was designed to explore Malaysian chemistry teachers' knowledge, awareness and practice on green chemistry. The quasi-experimental method was employed to seek the effectiveness of student-initiated green chemistry experiments on their achievement in the topic and their awareness on green chemistry practices.

Sample

A total of 269 Malaysian secondary school teachers and 77 Malaysian secondary school chemistry students. 38 students were undergoing traditional chemistry experiment (control group) and 39 students developed and carried out green chemistry experiments (experimental group) for the topic of Electrochemistry. First, demographic information of respondents (teachers) involved in the survey is shown in Table 1.

Table 1. Distribution according to school type, race, gender and teaching experience

	Frequency (Percentage)		
	National school n = 136 (50.6)	Private school n = 133 (49.6)	Total n = 269 (100.0)
Gender			
Male	34 (12.6)	33 (12.3)	67 (24.9)
Female	102 (37.9)	100 (37.2)	202 (75.1)
Race			
Malay	98 (36.4)	76 (28.3)	174 (64.7)
Chinese	19 (7.1)	47 (17.4)	66 (24.5)
Indian	19 (7.1)	10 (3.7)	29 (10.8)
Teaching Experience			
Less than 3 years	36 (13.4)	25 (9.3)	61 (22.7)
4 to 10 years	47 (17.5)	62 (23.0)	109 (40.5)
More than 10 years	53 (19.7)	46 (17.1)	99 (36.8)

A total of 269 teachers were involved as respondents, a total of 136 teachers (50.6%) were from national schools (government-funded) and the remaining 133 people (49.6%) were private school teachers (self-funded). Gender analysis found 67 male teachers (24.9%) and 202 female teachers (75.1%) answered the questionnaire. The composition according to race revealed the Malays made up most of them with a total of 174 respondents (64.7%) followed by the Chinese 66 (24.5%) and Indians 29 (10.8%). No other races were involved in the study. Their teaching experience was divided into three categories; less than 3 years (n = 61 (22.7%), 4 to 10 years (n = 109 (40.5%) and over 10 years (n = 99 people (36.8%).

Table 2 below shows the demographic data of respondents (students) involved in the quasi-experimental study. A total of 77 students were involved in this study. The 77 students were divided into two groups; the experimental group (n = 40) was involved in designing green chemistry experiments and the control group (n = 37) carried out the traditional electrochemistry experiments based on the textbook given by the ministry.

Table 2. Distribution of students by gender and race

Race	Control group			Experiment group		
	Male	Female	Total	Male	Female	Total
Malay	12	15	27	10	14	24
Chinese	4	2	6	3	6	9
Indian	2	2	4	3	4	7
Total (Percentage)	18 (23.3%)	19 (24.7%)	37 (48.1%)	16 (28.85)	24 (31.15)	40 (51.9%)

Instruments

Two sets of instruments were employed in the study. First, the questionnaire of the survey consisted of 48 items, adapted from Badrulhisham (2016). The questionnaire examined three constructs of chemistry teachers' knowledge, awareness and practice on green chemistry. The validity of the reconstructed questionnaire was estimated by two experts, measured by the Cohen's kappa index (0.94). The reliability analysis of the questionnaire was estimated during the pilot study which involved 30 teachers and the results yielded high reliability measured by the Cronbach's alpha index (0.89) (Beck & Gable, 2001; Pallant, 2001). Second, the 20-item test on Electrochemistry was constructed based on Malaysian secondary school chemistry syllabus (KPM, 2018). It is a paper and pencil test in the topic of Electrochemistry which was employed to gauge students' grasp of the topic. The content validity from another two experts for the test was 1.00 and inter-rater reliability index estimated during the pilot test with 15 students reported high reliability index for the test (1.00). The test on awareness was adapted from Raman & Abu Bakar (2019). It consisted of 25 MCQ items which required respondents to choose one best answer to the items. The validity and reliability of the test was also estimated during the pilot study, which yielded high validity and reliability levels with Cohen's kappa index of 0.94 and reliability index, r of 0.90 (Beck & Gable, 2001; Pallant, 2001).

Research Procedures

The survey was conducted via an online survey platform, blasted to all secondary schools nationwide for a month. 269 responses were recorded. Data of the survey was later analyzed using descriptive statistics (frequency and percentage). Meanwhile 3 schools were selected for the quasi-experimental study to evaluate the impact of student-initiated green experiments on their achievement on the topic and their awareness of green chemistry practices. Pre-test on the topic of Electrochemistry was given to both groups prior to the treatments. The control and experimental groups were carefully formed so they would be equivalent in terms of performance and gender ratio. The control group then proceeded with direct teaching using conventional chemistry experiments from Malaysian practical textbook provided by the Ministry of Education. The control group managed to finish off the topic in six school periods. At the same time, the treatment group started to design green chemistry experiments of the topic. Research team then guided the participants to research on the 12 principles of green chemistry; such as using benign materials used in daily life and by downsizing the amount of chemicals used. Participants tried out their ideas first before refining the green experiments. The control group finished their lessons in 4 teaching periods earlier than the treatment group. Table 3 demonstrates brief descriptions of some of the green chemistry experiments developed by the treatment group.

Table 3. Student-initiated green chemistry experiments in electrochemistry

Electrolysis experiment	Conventional		Green chemistry experiments	
Factors Affecting Electrolysis (Type of Electrode)	Active Electrodes	Inert Electrodes	Active Electrodes	Inert Electrodes
	Copper	Carbon	Old Copper Wires	Pencils
Production of Electricity from a Chemical Reaction in a Chemical Cell	Mg strip, copper strip, NaCl 1.0 mol dm^{-3}		Piece of zinc strip (battery body), 1 cent Malaysian coins, lime juice	
Building an Electrochemical Series Based on Potential Differences Between Metals	Aluminium strips Zinc strips Iron strips Silver strips		Aluminium foil Battery body Iron nails Old watches	

Tin strips	Sardine cans

After treatments, both groups were given the post-tests, and results from both the pre and post-tests were then analysed.

RESULTS AND DISCUSSION

Research question 1: To identify Malaysian chemistry teachers' level of knowledge, awareness and practices on green chemistry practices.

Level of Knowledge, Awareness and Green Chemistry Practice of the Malaysian Secondary School Teachers

Data from the survey were analysed to determine the level of green chemical awareness for each construct. Using the summated rating scale method, raw data were categorized into three class intervals; high, medium and low for each construct. Table 4 shows the score for each class interval and levels for each green chemistry constructs studied.

Table 4. Class interval and level for each green chemistry construct

Green chemistry constructs	Class interval	Level
Knowledge	24.0 – 56.0	Low
	57.0 – 88.0	Average
	89.0 – 120.0	High
Awareness	13.0 – 30.3	Low
	30.4 – 47.6	Average
	48.7 – 65.0	High
Practice	22.0 – 51.3	Low
	51.4 – 80.7	Average
	80.8 – 120.0	High

Table 5 below shows the results of descriptive analysis for the level of green chemistry knowledge among secondary school teachers based on location of school. The analysis found the level of green chemistry knowledge of teachers is at a moderate level, i.e., the overall score is 84.5 while the mean scores are 85.2 and 83.6 for urban and rural schools respectively.

Table 5. Level of green chemistry knowledge among teachers

Score range	Level	Locality		Total
		Urban	Rural	
24.0 – 56.0	Low	4 (1.5%)	2 (0.7%)	6 (2.2%)
57.0 – 88.0	Average	79 (29.4%)	90 (33.5)	169 (62.9%)
89.0 – 120.0	High	53 (19.7%)	41 (15.2%)	94 (34.9%)
N		136	133	269
Mean		85.2	83.6	84.5
Sd		12.7	10.1	11.5

Results showed respondents had a high level of green chemistry awareness. The overall mean is 48.3; and 48.2 and 48.4 for urban and rural teachers respectively. Overall, 65.8% of respondents had high level of green chemistry awareness (urban teachers, 32.3% and rural teachers, 33.4%). Table 6 below displays the level of green chemistry awareness among secondary school teachers.

Table 6. Level of green chemistry awareness among teachers

Score range	Level	Locality		Total
		Urban	Rural	
13.0 – 30.3	Low	7 (2.6%)	7 (2.6%)	14 (5.2%)
30.4 – 47.6	Average	42 (15.6%)	36 (13.4%	78 (29.0%)
47.7 – 65.0	High	87 (32.3%)	90 (33.4%)	177 (65.8%)
N		136	133	269
Mean		48.2	48.4	48.3
Sd		8.7	8.2	8.4

Table 7 provides an overview of the level of green chemistry practices among the respondents studied. Table 7 shows the overall level of green chemistry practice among teachers is at a moderate level (mean = 79.5). Results revealed the level of green chemistry practice of urban teachers is moderate (mean = 77.9) while the level of green chemistry practice of rural teachers is high (mean = 81.1). Most urban teachers show a moderate level of green chemistry practice (27.5%) and most rural teachers show a high level of green chemistry practice (26.7%). Hence the overall results of the survey revealed teachers have a moderate level of green chemistry knowledge and practice but have a high level of awareness. Teacher's high awareness of green chemistry do not seem to be translated into practice.

Table 7. Level of green chemistry practice among teachers

Score range	Level	Locality		Total
		Urban	Rural	
22.0 – 51.3	Low	7 (2.6%)	5 (1.9%)	12 (4.5%)
51.4 – 80.7	Average	74 (27.5%)	56 (20.8%)	130 (48.3)
80.8 -120.0	High	55 (20.5%)	72 (26.7%)	127 (47.2%)
N		136	133	269
Mean		77.9	81.1	79.5
Sd		13.8	11.5	12.81

Research question 2: To identify differences in students' achievement in the topic of Electrolysis between students who did the conventional chemistry experiments from the textbook with those who developed their own green chemistry experiments.

T-Test Results of Experimental and Control Group of Achievement in Electrochemistry

H_{01}: There is no significant difference in the achievement of the control and treatment groups in the pre-test. To test H_{01}, an independent t-test was used, and the results are shown as in Table 8.

Table 8. T-test results of experiment and control group achievement in the pre-test

Group	Mean	Mean diff.	Sd. Difff.	t	df	Sig. (2-tailed)
Experiment	15.00	0.44	2.534	0.868	75	0.394
Control	14.56					

*Significant level 0.05

Based on the t-test results in Table 8, the mean score of the experimental group was 15.00 while the control group was 14.56 ($t = 0.868$, $p > 0.05$). This implied no significant difference between

both groups in terms of achievement in pre-test, and both groups seemed to be equivalent in terms of their prior knowledge of the topic. Hence, H_{01} could not be rejected. H_{02} There is no significant difference in the achievement of the control and treatment groups in the post-test. To test H_{02}, an independent t-test was used, and the results are shown as in Table 9.

Table 9. T-test results of experiment and control group achievement in the post-Test

Group	Mean	Mean diff.	Sd. Difff.	t	df	Sig. (2-tailed)
Experiment	18.88	0.52	2.12	5.933	75	0.289
Control	18.36					

*Significant level 0.05

Based on the t-test results in Table 9, the mean score of the experimental group was 18.88 while the control group was 18.36 ($t = 5.933$, $p > 0.05$). This implied no significant difference between both groups in terms of achievement in the post-test. This indicated green chemistry experiments do not seem to have a strong impact on student achievement in the topic. Both groups seemed to yield almost equal performance in the post-test. Hence, H_{02} could not be rejected.

A mixed method study by Karpudewan et al. (2011) however, found the green chemistry curriculum produces differences in student achievement. Kolopajlo (2017) examined methods for teaching or pedagogy of green chemistry suggesting the use of guided and open inquiry methods and implied teaching methods through description need to be transformed into investigative and constructivist-based teaching. Another study by Andraos & Dicks (2012) implemented an analysis of the effectiveness of green chemistry teaching that focuses on undergraduate students, among the strengths of green chemistry teaching is that it could be integrated into existing or existing subjects; and practical teaching remains the best method in teaching green chemistry.

Research question 3: To identify differences in students' awareness of green chemistry between students who did the conventional chemistry experiments from the textbook with those who developed their own green chemistry experiments in Electrochemistry.

Post-Test Results of Experimental and Control Group Awareness of Environmental Sustainability

H_{03}: There is no significant difference in student awareness of the control and treatment groups in the post-awareness test.

Table 10. Independent T-test of the post-awareness test

Group	Mean	Mean diff.	Sd. diff.	t	df	Sig. (2-tailed)
Experiment	68.6	31.8	1.112	-7.866	75	.000
Control	36.8					

*Significance level 0.05

The post-test results demonstrate there was significant difference in the post-test mean scores between the experimental and control groups, ($t = -7.866$, and $p < 0.05$). The results indicate the awareness of the experiment group seemed to be higher (mean = 68.6) than the control group (mean = 36.8). Hence, instilling green chemistry in the curriculum is utmost important as green chemistry is the use of chemistry for pollution prevention (Burmeister & Eilks, 2014; Haack &

Hutchison, 2016) and it opens up opportunity for students to gain basic knowledge in the using of chemistry in a sustainable way to build a sustainable society. A research done by Milton Rokeach proved that students showed significant increase of environmental awareness between 3 and 5 weeks of treatment (Karpudewan et al., 2012). Therefore, integrating green chemistry in the curriculum may bring about changes in students to secure a healthy environment for future generations (Hjeresen et al., 2000).

CONCLUSION

The overall results of the survey revealed teachers have a moderate level of green chemistry knowledge and practice but have a high level of awareness. Teacher's high awareness of green chemistry do not seem to be translated into green chemistry practice. The quasi-experimental results revealed no significant difference in the achievement between students undergoing traditional chemistry experiments and the green chemistry experiments. Nevertheless, students participated in designing green chemistry experiments were found to have higher level of green chemistry awareness compared to the control group. This study recommends that teachers should apply their knowledge and awareness in green chemistry to empower students with suitable mechanisms to address sustainable environment issues in classroom or laboratory instruction to promote sustainable practices among school community.

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