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Siti Rabiatuladawiyyah Bt Mohd Nawawi, Ruhizan Bt Mohammad Yasin

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Malaysian Student's and Teacher's Knowledge on Solar Energy and PV-Solar Technology

Siti Rabiatuladawiyyah Bt Mohd Nawawi, Prof. Dr. Ruhizan Bt Mohammad Yasin
Faculty of Education, Universiti Kebangsaan Malaysia
Email: adawiyatun.edu@gmail.com, ruhizan@ukm.edu.my

Abstract
The shift to large-scale use of renewable energy (RE) in order to achieve sustainable development has indirectly caused the solar energy industry continue to grow and require a great deal of skilled labour causes a necessity for teachers and youngsters to be well equipped with the knowledge and skills needed to meet the demand of this solar energy industry. Thus, this study aims to identify the level of knowledge of teachers and students about solar energy and PV-solar technology as well as their awareness and desire to explore the use of solar energy and PV-Solar technology. This research uses survey research method involving 100 teachers and 600 students in Petaling (urban) and Hulu Terengganu (rural) districts in Malaysia. The findings shows that the level of teachers' and students' knowledge on solar energy and PV-Solar technology are weak. Low awareness on energy sustainability and solar energy, and moderate desire to explore the use of solar energy and PV-Solar technology. Therefore, further research on the methods to increase teachers' and students' knowledge on solar energy and PV-Solar technology need to be done in order to meet the great deal of skilled labour in this Solar Energy and PV-Solar technology industry in future.
Keywords: Solar Energy, Photovoltaic Technology, Renewable Energy, STEM, ESD

Introduction
Knowledge is the main foundation of a learning that determines the formation of individual actions and attitudes. Strengthening knowledge of STEM and sustainability is essential to ensure that students are able to apply their knowledge in a real -world context. The concept of Education for Sustainable Development (ESD) encourages human beings to be sensitive to their actions in improving lives and lifestyles (Rosman et al., 2019). The UNESCO inspired idea of ESD is likely to change the direction of education systems, basic structures, teaching, and learning (Watanabe, 2015). The general purpose of ESD is to integrate the principles and practices of sustainable development into all aspects of education and learning, driving change in knowledge, values, and attitudes in a vision to create a more sustainable and just society for all (Carm, 2013).

The shift to large-scale use of renewable energy (RE) is one of the actions to achieve sustainable development. Due to the energy constraints and environmental pollution facing the world today (Zakaria et al., 2019 & Hong et al., 2019), the use of RE can reduce carbon emissions, solve air pollution and achieve sustainable development. In Malaysia alone, the reduction of up to an estimated 1,070 tonnes of carbon dioxide emission gas has been successfully accomplished through the Photovoltaic Technology Project launched in July 2005 (Hamid et al., 2019). Encouragement of private use of solar energy has also been carried out for a long time by the Sustainable Energy Development Authority (SEDA) which provides an incentive called Feed-in-Tariff (FiT) to consumers who use solar panels at home or in office buildings where electricity is available. The resulting energy can be channelled to the national grid and the energy will be purchased by TNB (Hamid et al., 2019; Rajamanickam, 2016). In Sarawak, solar energy is widely used in rural areas and is not competitive to be connected to the national grid and it is suitable for use in rural areas that have difficulty getting electricity supply (Hamid et al., 2019). Looking at the growing demand for solar energy and photovoltaic technology, it is becoming a necessity to produce human capital that is capable of meet the needs of this solar energy industry. To achieve this goal, of course, the education sector must play a key role. The education system plays an important role in the development of a country, especially for developing countries such as Malaysia. Education is very important to encourage society to improve skills and usability with more systematic techniques, acquire knowledge, and emphasize the importance of achieving a balanced life (Watanabe, 2015).

Nevertheless, knowledge alone is not sufficient to shape action because an individual’s beliefs (knowledge and experience) determine an individual’s behaviour (Ajzen, 1991). The Theory of Reasoned Action (TRA) by Fishbein & Ajzen (1975) states that a person’s behaviour is determined by their intention to behave in such a way, whereas this intention stems from attitude; which describes the function of each behaviour in a subjective norm. Intention reflects the extent to which a person tends to plan, and perform certain behaviour. Intention is conceptualized as a function of two constructs (attitudes and subjective norms) based on beliefs. Attitudes are positive or negative assessments of performing a behaviour, while subjective norms reflect the belief that the existence of significant other individuals wants them to perform the behaviour (Paquin & Keating, 2017; Brown, 2018). As such, individual actions are reflection of the beliefs that are built. Education plays an important role in building individual trust; thus, empowerment of STEM knowledge and sustainability must be accompanied by learning experiences in order to shape individual positive behaviours and attitudes.

Therefore, researchers need to explore the level of teachers’ and students’ knowledge about solar energy and solar PV technology because looking at past research trends related to ESD, studies on solar energy education and PV technology mostly involve educational innovation for higher education sector (Hassouni et al., 2019; Li et al., 2018; Rahmawati et al., 2018) in a foreign context (Machuve & Mkenda, 2019; Llorente, 2017; Islam, 2017). The lack of research related to knowledge about solar energy and PV-Solar technology among secondary school teachers and students makes it difficult to obtain existing information on the knowledge of teachers and students about solar energy and solar PV technology. Exploration of simple energy sustainability practices among teachers and students and their desire to explore the use of solar energy and PV-Solar technology is also necessary to find out the level of motivation and existing interest of teachers and students to use solar energy and PV-solar technology in their daily lives, while expanding its use in the community.

Research Aim, Objectives, Questions and Hypothesis

This study aims to identify the level of knowledge of teachers and students about solar energy and PV-solar technology, simple energy conservation practices among teachers and students as well as their desire to explore the use of solar energy and PV-Solar technology. Table 1.1 shows the objectives of the study, the research questions and the hypotheses of this study.

Table 1.1 Research Objective, Questions and Hypothesis

	Research Objective	**Research Question**	**Hypothesis**
1	To identify the level of knowledge of teachers and students about solar energy and PV-Solar technology	What is the level of knowledge of teachers and students about solar energy and PV-Solar technology?	NA
2	To identify differences in the level of knowledge about solar energy and PV-solar technology between teachers and students	Is there a significant difference in the mean score of knowledge about solar energy and PV-solar technology between teachers and students?	H_0: There is no significant difference for the mean score of knowledge on solar energy and PV-solar between teachers and students. H_a: There is a significant difference in the mean score of knowledge about solar energy and PV-solar between teachers and students.
3	To identify simple practices of energy conservation among teachers and students	Do teachers and students practice simple energy conservation practices?	NA
4	To identify the level of awareness of teachers and students on energy sustainability and solar energy.	What is the level of awareness of teachers and students about energy sustainability and solar energy?	NA
5	To identify the differences between the level of awareness on energy sustainability and solar energy between teachers and students.	Is there a significant difference in the mean score of the level of awareness on energy sustainability and solar energy between teachers and students?	H_0: There is no significant difference for the mean score of awareness level on energy sustainability and solar energy between teachers and students. H_a: There is a significant difference in the mean score of the level of awareness on energy sustainability and solar energy between teachers and students.

6	To identify teachers' and students' desire to explore the use of solar energy and Solar PV technology.	Is there a desire to explore the use of solar energy and solar PV technology among teachers and students?	NA
7	To identify the relationship between the level of awareness on energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology	Is there a significant relationship between the level of awareness about energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology?	H_0: There was no significant relationship between the level of awareness about energy and energy sustainability with the desire to explore solar energy consumption and PV-solar technology. H_a: There is a significant relationship between the level of awareness about energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology.

Materials and Methods

The researchers used survey method, which is a quantitative research design. This questionnaire survey method was conducted to obtain quantitative data that can be generalized to the research population (Creswell, 2012). Therefore, a survey questionnaire for this study was conducted on 100 teachers in the field of STEM and 600 students from schools around the District of Petaling, Hulu Terengganu and Kuala Terengganu. The findings of this survey provide empirical data on the needs of teachers and students in conducting solar energy education in schools. All statistical tests were conducted using the Statistical Package for the Social Sciences (SPSS, version 23). Differences were considered statistically significant at $p < 0.05$. Data for this study will be obtained from a questionnaire of solar energy education needs of teachers and students. Frequency analysis was used to present the data obtained.

Research Sample

The participants involved in this study consisted of two groups namely teachers and students. The selection of respondents in this study was selected using purposive sampling method. According to Chua (2016) sampling aims to refer to a sampling procedure where a group of subjects with certain characteristics are selected as study respondents. Participants of this study involved teachers and students of National Secondary School *Sekolah Menengah Kebangsaan* (SMK) in the area around the districts of Petaling and Hulu Terengganu. The location of this study was chosen because these areas have a relatively large number of schools in the urban and rural categories. The study involved 100 subject teachers related to STEM field and 600 form 4 students. The selected sample size was based on 5% share of population size (Chua, 2016). The estimated population of teachers for this study is 1960 while the population of students is 11690. The estimated population is based on data on the number of teachers and students released by the Ministry of Education Malaysia (MOE, 2020). Table 2.1 below is the method of calculation of the estimated sample size and population size performed.

Table 2.1 Summary of Population Size and Sample Size Calculations

Number of Secondary Teachers in Malaysia: 179,750 teachers Number of Secondary School Students in Malaysia: 2,037,433 students Number of Secondary Schools in Malaysia: 2440 Number of Schools involved in the Klang Valley: 54 Number of schools involved in Hulu Terengganu and Kuala Terengganu: 16	
	Estimation
Estimated number of STEM teachers in a school	
$\frac{179{,}750}{2440} \div 8 \times 3 \approx 28\ teachers$ *8: PT3 core subjects (BM, BI, Mat, Sc, History, Geo, RBT, PI)* *3: PT3 STEM Subjects (Sn, Mat, RBT)*	28 teachers
Estimated number of Form 4 students in a school	
$\frac{2{,}037{,}433}{2440} \div 5 \approx 167\ people$ *5: 5 forms in SMK*	167 students
Research population size	
Teacher: $28\ teachers \times 70\ schools$ = 1960 teachers	1960 teachers
Student: $167\ teachers \times 70\ school$ = 11,690 teachers	11690 students
Research sample size (based on 5% ratio of sample size to population size (Chua 2016))	
$\boldsymbol{Teacher's\ sample\ size} = 1960\ teachers \times 0.05 = 98\ teachers \approx 100\ teachers$	**100 teachers**
$\boldsymbol{Student's\ sample\ size} = 11{,}690\ students \times 0.05 = 585\ students \approx 600\ students$	**600 students**

Questionnaire for Teachers and Students

In this study, the questionnaire was conducted involving 100 STEM subject teachers in schools as well as 600 Form 4 students in *Sekolah Menengah Kebangsaan* (SMK) to identify the level of knowledge of teachers and students about solar energy and PV-solar technology, simple energy conservation practices among teachers and students as well as their desire to explore the use of solar energy and PV-Solar technology. Researchers developed two instruments namely questionnaires for teachers and students. Table 2.2 and table 2.3 show a summary of the reference sources as well as a description of the questionnaire items for each section.

Table 2.2 Summary of the development of teachers' and students' questionnaire items

Section	Item Description	Aim	Reference
Section A: Demographics of research participants	**Demographics** - 9 open-ended structured questions (for Teacher) - 9 open-ended structured questions (for Student)	To find out the background of the research participants.	NA
Section B: Energy Conservation Practices	- 6 questions using 4 scale Likert scale	To find out teachers' existing sustainability practices	NA
Section C: Awareness, Desire, and knowledge on solar energy and PV-solar technology	**Sub C1** - 15 questions using 4 scale Likert scale	To identify teachers' awareness of energy sustainability, solar energy and PV-solar technology	- Handbook for Solar Photovoltaic (PV) System (Insert Reff), - Education for Sustainable Development Goals Learning Objectives (SDG 13),
	SubC2 - 5 questions using 4 scale Likert scale	To identify the tendency of teachers to explore the use of solar energy and PV-Solar technology	
	Sub C3 - 20 questions using 4 scale Likert scale	To find out the existing knowledge of teachers about solar energy and PV-solar technology	

This questionnaire was divided into 3 main sections, (A) demographics of study participants, (B) energy conservation practices, and (C) level of knowledge about energy sustainability and solar energy. The questionnaire was self-developed by the researchers and used a four-value Likert scale as well as open-ended structured questions. For the student questionnaire form, section A only contains 7 open-ended structured questions.

Pilot Test

A pilot study is a study conducted on a small scale with the aim of improving and enhancing the validity and reliability of a research instrument (Creswell, 2012). By conducting a pilot study, researchers can identify the strengths and weaknesses of each instrument used. For this study, the researcher conducted a pilot study testing the instrument that is the questionnaire item.

For the instrument testing pilot study, the researchers conducted a pilot study involving 30 students and 30 teachers. Any weaknesses such as confusing questions as well as the appropriateness of item selection were also identified so that they could be corrected before the actual study and used as a guide during the actual study. Study participants were asked to mark sentences or words that were difficult to understand so that the researcher could make improvements, modifications and complete the tests and questionnaires. If an instrument has a high reliability value, then a second pilot study is not necessary. But the pilot study needs to be repeated if the reliability value of the instrument does not reach the desired level (Chua, 2016). Based on the pilot study conducted, the Cronbach's Alpha values obtained for each item are good as shown in tables 2.3.

Table 2.3 Reliability value of questionnaire items

No	Item	Number of Questions	Alpha Cronbach
1	Energy sustainability practices	6	0.884
2	Awareness of energy sustainability and solar energy	15	0.906
3	Desire to explore the use of solar energy and PV-Solar technology	5	0.914
4	Knowledge of solar energy and PV-Solar technology	20	0.910

Table 2.4 shows the reliability values of the teacher questionnaire items. Based on Table 2.4, all items have good Cronbach's Alpha values, namely energy sustainability practices ($n = 6$, $\alpha = 0.884$), awareness of energy sustainability and solar energy ($n = 15$, $\alpha = 0.906$), desire to explore solar energy consumption and PV-Solar technology ($n = 5$, $\alpha = 0.914$) and knowledge of solar energy and PV-Solar technology ($n = 20$, $\alpha = 0.910$). This indicates a good and quality teachers' and students' questionnaire to be used in the actual study.

Face and Content Validity

Questionnaires constructed by a researcher need to be tested for face validity and content validity (Chua, 2016). For this study, the face validity of the teacher and student questionnaire was done by 2 teachers and 2 lecturers consisting of a Malay language teacher (as the actual study was conducted in Malay) and an experienced physics teacher, as well as 2 lecturers who specialize in physics education.

Next, as for the content validity of the questionnaire, it was done by 2 lecturers. There are five categories of evidence in providing quality and effective validity namely validity evidence based on test content, reaction process, internal structure, relationship with test variables and consequences (Creswell, 2012). For this study for content-based validity of the test the researchers looked at themes, sentences, word usage, language and format based on Handbook for Solar Photovoltaic (PV) System as well as official document Education for Sustainable Development Goals Learning Objectives. To obtain an assessment, the researcher contacts experts in the field.

To obtain response-based validity, the researchers looked at the suitability of the instrument construction and the condition of the sample taking the actual test. Next for internal structure -based validity, the researchers looked for relationships between the variables and the force collection methods used.

Results

Demographics of Research Respondents

Researchers used a questionnaire method to obtain random and quantitative feedback from teachers and students. A total of 2 sets of questionnaires were distributed. 1 set of questionnaires was distributed to 100 teachers, while 1 set of questionnaires was distributed to 600 students. All respondents involved in this questionnaire were randomly selected and the demographic distribution of the respondents of this study can be seen in table 3.1 and table 3.2. Table 3.1 shows the demographic distribution of teacher questionnaire respondents by category (gender, teaching location, subjects taught, age, and teaching experience). Table 3.2 shows the demographic distribution of the respondents of the student questionnaire by category (gender and school location).

Table 3.1 Demographic distribution of teacher questionnaire respondents

Category		**Frequency**	**Percentage (%)**
Gender	Male	14	14
	Female	86	86
Teaching location	Urban	55	55
	Rural	45	45
Subject teaching	Science	22	22
	Mathematics	20	20
	Design and technology	28	28
	Physics	20	20
	Chemistry	3	3
	Biology	5	5
	Computer Science	2	2
Age	20-29 years old	1	1
	30-39 years old	44	44
	40-49 years old	37	37
	50-59 years old	18	18
Teaching experience	1-10 years	83	83
	11-20 years	0	0
	21-30 years	11	11
	31-40 years	6	6

Based on table 3.1, majority of teachers' respondents are female which is 86%. Teacher s' respondents from urban locations were more than rural with a percentage difference of 10%. In addition, the majority of teacher respondents involved were Design and technology (RBT) teachers. Most of the teachers involved in this questionnaire were in the age range of 30-39 years. Majority of the teachers involved in this questionnaire also had teaching experience of around 1-10 years.

Table 3.2 Demographics of student questionnaire respondents

Category		**Frequency**	**Percentage (%)**
Gender	Male	222	37
	Female	378	63
School location	Urban	300	50
	Rural	300	50

For the student questionnaire respondents, the number of female respondents are more than male respondents with a percentage of 63%. Nevertheless, the number of student respondents from schools in urban and rural areas is equal to the respective percentages of 50%.

Knowledge of Solar Energy and Solar PV Technology

Researchers conducted a test of knowledge of solar energy and PV-Solar technology on teachers and students. This knowledge test was included together in a set of teacher and student questionnaires distributed to the respondents. The test contained 20 items, placed in Section C, sub-section C3 in both of the questionnaires.

Research Question 1: What is the level of knowledge of teachers and students about solar energy and PV-Solar?

Table 3.3 and figure 3.1 show the frequency distribution of teachers' knowledge scores on solar energy and PV-Solar technology while Table 3.4 and figure 3.2 show the frequency distribution of students' knowledge scores on solar energy and PV-Solar technology.

Table 3.3 Distribution of teachers' knowledge scores on solar energy and PV-Solar

		F	**%**	**∑F**
Valid	.00	5	5.0	5.0
	1.00	3	3.0	8.0
	2.00	13	13.0	21.0
	3.00	17	17.0	38.0
	4.00	8	8.0	46.0
	5.00	12	12.0	58.0
	6.00	5	5.0	63.0
	7.00	7	7.0	70.0
	8.00	6	6.0	76.0
	9.00	8	8.0	84.0
	10.00	2	2.0	86.0
	11.00	3	3.0	89.0
	12.00	4	4.0	93.0
	14.00	3	3.0	96.0
	15.00	4	4.0	100.0
	Total	100	100.0	

Based on the distribution of teachers' knowledge scores on solar energy and PV-Solar technology in table 3.3, it shows that, the highest score that can be achieved by teachers (F = 4) is 15 (75% of the total score) while the lowest score (F = 5) is 0 (0% of the total marks). The majority of teachers (F = 17) got a score of 3 (15% of the total score). On average, the teacher achievement score as shown in figure 3.1 was 5.74 (28.7% of the overall score). This analysis indicates that, on average, teachers' knowledge scores on solar energy and PV-Solar technology is weak.

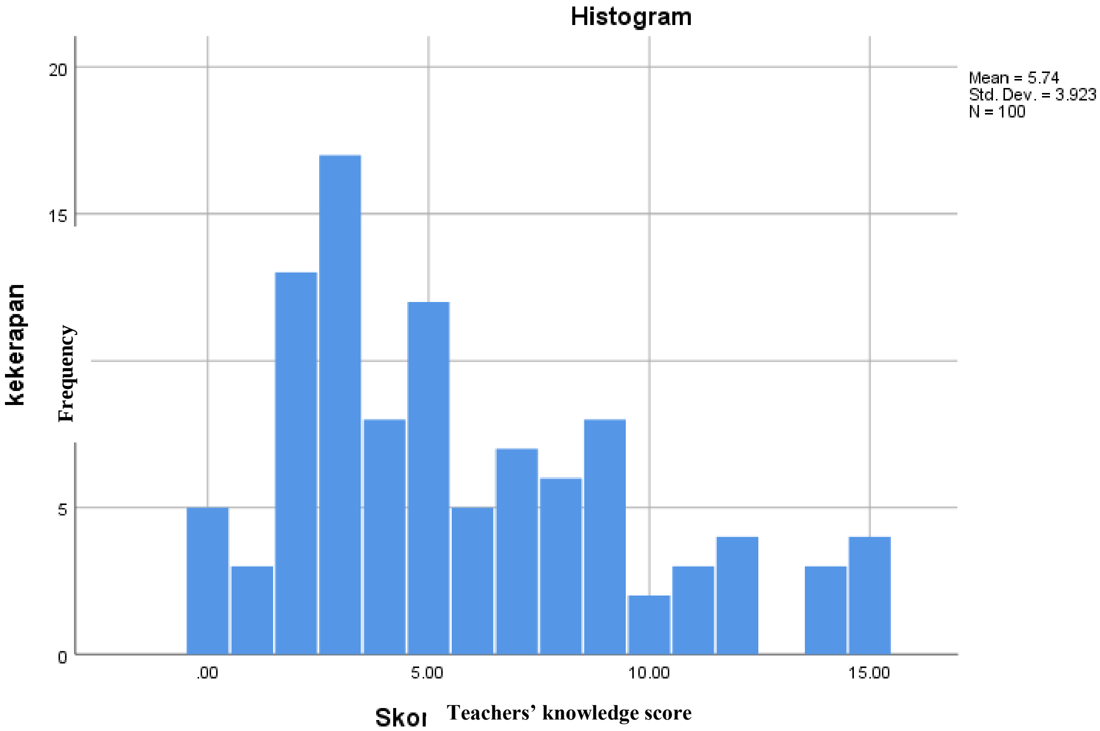

Figure 3.1 Distribution of teachers' knowledge scores on solar energy and PV-Solar

Interpretation of these findings shows the need to increase the level of knowledge and skills of teachers on solar energy and PV-Solar technology through some training courses/workshops. This is because teachers are the driving force behind the development of education in schools, if the level of teachers' own knowledge about solar energy and PV-Solar is still weak, how do teachers want to convey that knowledge to students? Therefore, teachers' training should be given attention in strengthening the knowledge and skills about solar energy and PV-solar technology among teachers.

Table 3.4 shows the distribution of students' knowledge scores on solar energy and PV-Solar technology.

Table 3.4 Distribution of students' knowledge scores on solar energy and PV-Solar

		F	%	∑F
Valid	.00	60	10.0	10.0
	1.00	72	12.0	22.0
	2.00	67	11.2	33.2
	3.00	95	15.8	49.0
	4.00	101	16.8	65.8
	5.00	39	6.5	72.3
	6.00	32	5.3	77.7
	7.00	50	8.3	86.0
	8.00	33	5.5	91.5
	9.00	31	5.2	96.7
	10.00	20	3.3	100.0
	Total	600	100.0	

The results in table 3.4 shows that, the highest score that students can achieve (F = 20) is 10 (50% of the total score) while the lowest score (F = 60) is 0 (0% of the total marks). The majority of students (F = 101) got a score of 4 (20% of the total score).

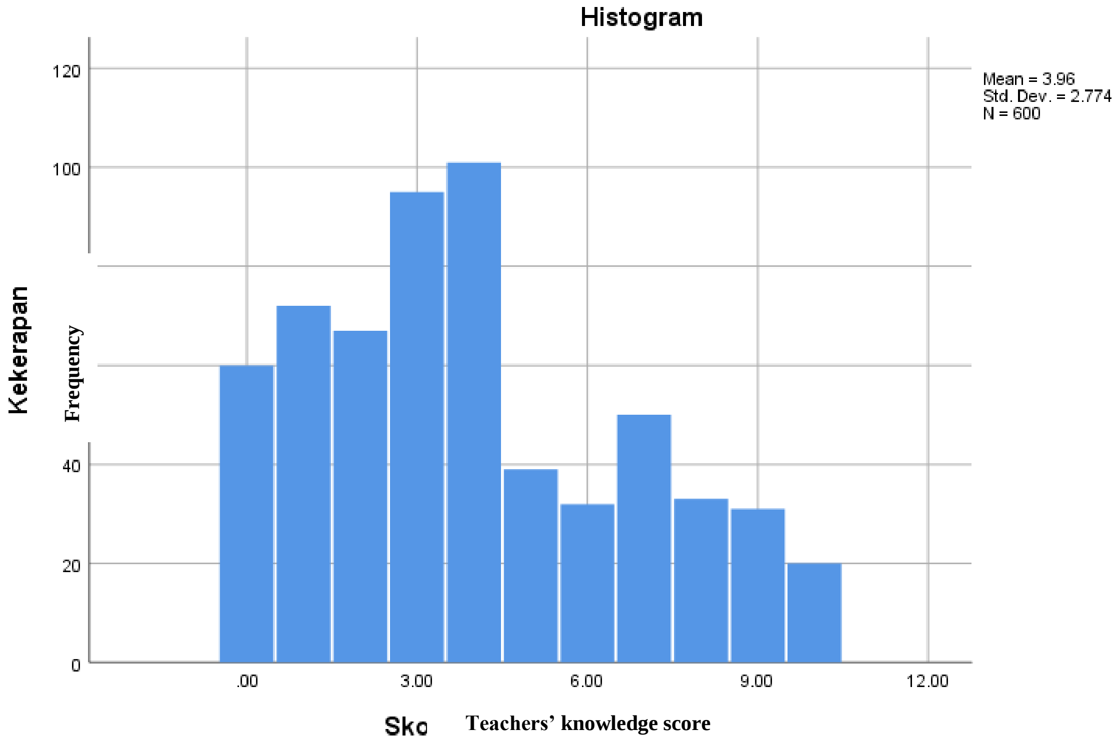

Figure 3.2 Distribution of student knowledge scores on solar energy and PV-Solar technology

On average, the student achievement score as shown in figure 3.2 was 3.96 (19.8% of the overall score). The analysis shows that students' knowledge on solar energy and PV-Solar technology is weak. Interpretation of these findings indicates the need to increase students' level of knowledge about solar energy and PV-Solar technology through this teaching and learning (T&L) of solar energy and PV-Solar technology. This is because students are the driving force behind the development of a country and will be the human capital that will fill job vacancies in the solar energy industry in the future. If the level of students' knowledge about solar energy and PV-Solar technology is still weak, how do students want to have high self-confidence and ability to venture into the solar industry?

Differences between the level of knowledge of teachers and students about solar energy and PV-Solar technology.

An analysis of the differences between the mean scores of teachers' and students' knowledge on solar energy and PV-solar technology was also conducted. The normality test on the mean score of knowledge about solar energy and PV-Solar between teachers and students was done first. Table 3.5 shows the test results of determining the nature of the normal distribution of mean knowledge scores on solar energy and PV-Solar between teachers and students.

Table 3.5: Test results for determining the nature of the normal distribution of mean scores of the knowledge on solar energy and PV-Solar technology between teachers and students

		Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Mean knowledge score on solar energy and PV-Solar.	Teacher	.155	100	.000
	Student	.152	600	.000

Based on table 3.5 the Kolmogorov-Smirnov test was conducted to test the normality of the mean data distribution of knowledge scores on solar energy and PV-Solar technology between teachers and students. Mean scores of the knowledge on solar energy and PV-Solar technology among teachers and students were both abnormal with a significant value of 0.000 ($p < 0.05$) which does not exceed the significant level. Since the mean scores of the knowledge about solar energy and PV-Solar technology of teachers and students were not normally distributed, a Mann-Whitney non-parametric equivalent test was conducted to see the difference of mean scores of the knowledge about solar energy and PV-Solar technology between teachers and students.

Research Question 2: Is there any significant difference in the mean score of knowledge about solar energy and PV-solar technology between teachers and students?

The Mann-Whitney test on the mean scores of teachers 'and students' knowledge of solar energy and PV-solar

H_0: There is no significant difference for the mean score of knowledge on solar energy and PV-solar technology between teachers and students.

H_a: There is a significant difference for the mean score of knowledge about solar energy and PV-solar technology between teachers and students.

Table 3.6 shows an analysis of significant differences for mean knowledge scores on solar energy and PV-solar technology between teachers and students.

Table 3.6 Analysis of significant differences for mean knowledge scores on solar energy and PV-solar between teachers and students

	Location	N	Mean Rank	Sum of Ranks
Knowledge of solar energy and PV-solar technology	Teacher	100	425.38	42538.00
	Student	600	338.02	202812.00
	Total	700		

The analysis in table 3.6 shows that there is a difference for the mean score of knowledge about solar energy and PV-solar technology between teachers and students. The mean score of the teachers' knowledge of solar energy and PV-solar technology was higher than that of students. Statistical test analysis in table 3.7 shows that these differences are significant. Table 3.7 shows the *Mann-Whitney* statistical test on the mean of knowledge scores on solar energy and PV-solar between teachers and students.

Table 3.7 *Mann-Whitney* statistical test on mean knowledge scores on solar energy and PV-solar between teachers and students

	Knowledge on solar energy and PV-Solar Technology
Mann-Whitney U	22512.000
Wilcoxon W	202812.000
Z	-4.026
Asymp. Sig. (2-tailed)	.000

a. Group of variables: group (teachers and students)

Table 3.7 shows that there is a significant difference for the mean score of knowledge on solar energy and PV-solar between teachers and students (U = 22512.00, p = .000), $p < 0.05$ and thus reject the H_0. In conclusion, there is a significant difference for the mean score of knowledge about solar energy and PV-solar technology between teachers and students. Teachers have higher knowledge of solar energy and PV-solar technology than students.

Energy sustainability practices

The energy sustainability practices in this study referred to simple steps taken by consumers as one of the ways to maintain energy sustainability. These simple steps are like the items described in table 3.8. The purpose of the assessment on energy sustainability practices created in the questionnaire form is to identify whether simple measures to maintain this energy sustainability are done or not among teachers and students. This is because, based on the analysis of these energy sustainability practices, researchers can assess the extent to which these energy sustainability practices have been applied in the daily lives of teachers and students.

Research Question 3: Do teachers and students practice simple energy conservation practices?

The questionnaire on energy sustainability practices contained 6 items and was included in a set of questionnaires distributed to teachers and students. In the teacher and student questionnaire, an assessment of these energy sustainability practices was placed in section B. Table 3.8 shows the percentage of frequency of assessments given by teachers and students on their energy sustainability practices.

Table 3.8 Energy sustainability practices among teachers and students

	Energy sustainability practices	Rating (percentage frequency %)					
		No		Unsure		Yes	
		T	S	T	S	T	S
1	I use electrical appliances that have electrical energy efficient technology	4	7	16	25.5	80	67.5
2	I use electronic goods that have electrical energy efficient technology	4	4.7	19	42.3	77	53
3	I am aware to the value of my residential electricity bill each month	2	31.3	5	38.5	93	30.2
4	I practice energy saving measures in my residence	1	12.8	8	29.3	91	57.8
5	I use renewable energy to generate electricity	61	44	25	35.7	14	20.3
6	I am sensitive to environmental issues and climate change that occur due to electricity generation	11	18	35	59.5	54	22.5

Notes: Teacher (T); Student (S)

Based on the frequency percentage in table 3.8, it was found that the majority of teachers and students use electrical appliances that have electrical energy efficient technology (teachers: 80%, students: 67.5%); using electronic goods that have energy efficient technology (teachers: 77%, students: 53%); adopting current energy saving measures in their homes (teachers: 91%, students: 57.8%); but do not use renewable energy to generate electricity in their homes (teachers: 61%, students 44%). However, only the majority of teachers (93%) are sensitive to the value of their monthly residential electricity bills, but not for students. The majority of students (38.5%) were unsure of the value of their monthly residential electricity bills. In addition, the majority of teachers are also sensitive to environmental issues and climate change that occur due to electricity generation (54%), but among students, the majority of students are less sure about environmental issues and climate change that occurs. due to electricity generation (59.5%). In conclusion, based on the percentage distribution of energy sustainability practices in table 3.8, it is found that these energy sustainability practices are more practiced among teachers than students.

Awareness of Energy Sustainability and Solar Energy

An analysis of the awareness of teachers and students on the sustainability of energy and solar energy was also conducted to identify the existing level of awareness of teachers and students on the sustainability of energy and solar energy.

Research Question 4: What is the level of awareness of teachers and students about energy sustainability and solar energy?

Table 3.9 shows the Percentage distribution of the level of awareness of teachers and students on energy sustainability and solar energy.

Based on the percentage distribution of the frequency of the level of awareness of teachers and students on energy sustainability and solar energy, it was found that most of the highest frequency percentages for each item were in the range of no, low and medium.

Table 3.9 Percentage distribution of teachers and students' level of awareness on energy sustainability and solar energy

	Awareness of energy sustainability	Awareness level (percentage frequency %)							
		None 1		Low 2		Medium 3		High 4	
		T	S	T	S	T	S	T	S
1	Knowledge of energy sustainability	3	1.3	14	44.7	68	52.5	15	1.5
2	Knowledge of solar energy	4	9	11	26.8	70	50.8	15	13.3
3	Knowledge of solar PV-Solar technology	7	40.2	15	35.3	39	19.2	3	5.3
4	Frequency of reading or hearing about energy sustainability	5	12	25	36.5	58	35.7	12	15.8
5	Frequency of reading or hearing about solar energy	4	8.8	25	35.7	59	46.3	12	9.2
6	Frequency of reading or hearing about PV-solar technology	13	38.8	51	44.2	32	15.2	4	1.8
7	Ability to explain to the public about energy sustainability	9	35.7	45	41.7	39	17.7	7	5
8	Ability to explain to the public about solar energy	4	33.8	41	40.3	49	15.5	6	10.3
9	Ability to explain to the public about PV-solar technology	17	43.3	54	37.5	24	10.7	5	8.5
10	Sensitivity to energy sustainability issues	5	10.3	32	49.0	48	38.8	15	1.8
11	Sensitivity to solar energy related issues	3	19.2	38	44.2	46	28	13	8.7
12	Sensitivity to issues related to PV-solar technology	14	32.2	47	52.5	36	15.3	3	0
13	Skills in using solar energy to generate electricity	19	35.3	44	31.7	36	24.2	1	8.8
14	Skills in applying PV-Solar technology to generate electricity	25	49.0	49	30.3	25	19.0	1	1.7
15	Consumption of solar-derived electricity in daily life	23	40	40	25.5	32	22.2	5	12.3

Notes: teacher (G); Student (M), 0% (1); 1-40% (2); 41-70% (3); 71-100% (4).

This indicates that the majority of teachers and students feel that their awareness of energy sustainability and solar energy is still at a moderate level and below. In addition, 40.2% of students stated that they have no direct knowledge of PV-Solar technology, 43.3% of students are not able to explain to the public about PV-Solar technology, 35.3% of students do not have the skills to generate electricity using solar energy, 49% of students do not have the skills to generate electricity using PV-Solar technology, and 40% of the students do not have the skills to use solar energy-sourced electricity in their daily lives. This analysis proves the need to improve their knowledge and skills about PV-Solar in order for them to be able to apply that knowledge and skills in daily life. Awareness of solar and PV-solar energy among teachers is also relatively low based on the frequency percentage distribution in table 3.9.

Descriptive analysis of the awareness of teachers and students on energy sustainability and solar energy was carried out to find out the mean score of the level of awareness of teachers and students on the sustainability of energy and solar energy. Table 3.10 shows a descriptive analysis of teachers 'awareness of energy sustainability and solar energy.

Table 3.10 Descriptive analysis of teachers' awareness of energy sustainability and solar energy

	N	Minimum	Maximum	Mean	Std. Deviation
Sustainability awareness	100	1.00	4.00	2.4933	.51454
Valid N (listwise)	100				

Table 3.11 shows a descriptive analysis of students 'awareness of energy sustainability and solar energy

Table 3.11 Descriptive analysis of students 'awareness of energy sustainability and solar energy

	N	Minimum	Maximum	Mean	Std. Deviation
Sustainability awareness	600	1.07	3.33	2.1402	.51454
Valid N (listwise)	600				

Based on the descriptive analysis in tables 3.10 and 3.11, it was found that the awareness of teachers and students on energy sustainability and solar energy were low with mean scores of 2.49 and 2.14 respectively. Although the mean score of teachers' awareness level on energy sustainability is higher than that of students, it is still at a low level. This proves that, action is necessary to be taken in order to increase the awareness of teachers and students on energy sustainability and solar energy.

Differences in awareness about energy awareness and solar energy between teachers and students

To identify whether there is a significant difference in the level of awareness about energy and solar energy awareness between teachers and students, researchers conducted a normality test on the mean level of awareness about energy and solar energy sustainability between groups first. Table 3.12 shows the test results of determining the nature of the normal distribution of the level of awareness of teachers and students on energy sustainability and solar energy.

Table 3.12 Results of the test to determine the nature of the normal distribution of the level of awareness of teachers and students on energy sustainability and solar energy.

		Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Level of awareness on energy sustainability and solar energy.	Teacher	.097	100	.022
	Student	.068	600	.000

Based on table 3.12 the Kolmogorov-Smirnov test was conducted to test the normality of the frequency data distribution of the level of awareness on energy sustainability and solar energy by group. Mean level of awareness on energy sustainability and solar energy among teachers and students were both abnormal with significant values of 0.022 and 0.000 ($p < 0.05$) respectively, which did not exceed the significant level. Since the mean levels of awareness on energy sustainability and solar energy for both groups (teachers and students) were not normally distributed, a Mann-Whitney non-parametric equivalent test was conducted to see the difference between the mean scores of awareness levels on energy sustainability and solar energy between teacher and student.

Research Question 5: Is there a significant difference in the mean score of the level of awareness on energy sustainability and solar energy between teachers and students?

Mann-Whitney test on mean level of awareness about energy sustainability and solar energy of teachers and students

H_0: There is no significant difference in the mean score of awareness level on energy sustainability and solar energy between teachers and students.

H_a: There is a significant difference in the mean score of the level of awareness on energy sustainability and solar energy between teachers and students.

Table 3.13 shows the mean difference of awareness level scores on energy sustainability and solar energy between teachers and students.

Table 3.13 Analysis of mean differences in awareness level scores on energy sustainability and solar energy between teachers and students

	Location	N	Mean Rank	Sum of Ranks
Awareness of energy sustainability and solar energy	Teacher	100	464.83	46482.50
	Student	600	331.45	198867.50
	Total	700		

The analysis in table 3.13 shows that there is a difference for the mean score of the level of awareness on energy sustainability and solar energy between teachers and students. Mean scores of teachers' awareness level on energy sustainability and solar energy were higher than students. Statistical test analysis in table 3.14 shows that these differences are significant. Table 3.14 shows the Mann-Whitney statistical test on the mean score of awareness level on energy sustainability and solar energy between teachers and students.

Table 3.14 Mann-Whitney statistical test on mean scores of awareness level on energy sustainability and solar energy between teachers and students

	Awareness level
Mann-Whitney U	18567.500
Wilcoxon W	198867.500
Z	-6.113
Asymp. Sig. (2-tailed)	.000

a. Group of variables: group (teachers and students)

Findings from table 3.14 show that there is a significant difference for the mean score of awareness level on energy sustainability and solar energy between teachers and students with value (U = 18567.50); p = 0.000, p <0.05 thus rejecting H_0. In conclusion, there is a significant difference for the mean score of the level of awareness on energy sustainability and solar energy between teachers and students. Teachers have a higher level of awareness about energy sustainability and solar energy than students.

Desire to Explore the Use of Solar Energy and Solar PV Technology

Research Question 6: Is there any desire to explore the use of solar energy and solar PV technology among teachers and students?

Table 3.15 shows the percentage distribution of the frequency of the desire level to explore solar energy consumption and Solar PV technology. Based on table 3.15, 35% of teachers and 35.2% of students have a moderate desire to know how to install and operate photovoltaic technology in residential areas. In addition, the majority of students (35.3%) have a low desire to switch to solar energy as the main source of electricity generation at home. The majority of teachers (42%) have only a modest desire to switch to solar energy as the main source of electricity generation at home.

Table 3.15 Percentage distribution of desire levels to explore solar energy consumption and Solar PV technology

	Desire to explore the use of solar energy and Solar PV technology	Desire level (percentage frequency %)							
		None 1		Low 2		Moderate 3		High 4	
		T	S	T	S	T	S	T	S
1	I would like to know how to install and operate photovoltaic technology in a residential area	13	17.3	24	30.3	35	35.2	28	17.2
2	I feel it is necessary to switch to solar energy as the main source of electricity generation at home	3	10.3	25	35.3	42	28.8	30	27.3
3	I want to have enough knowledge about the advantages of solar energy so that I can apply it at home and teach it to students *or (student question)* *to convince my parents that they turn to solar energy to generate electricity*	2	16.5	20	26.8	41	29.0	37	27.7
4	I would like to be exposed to various reliable sources to obtain information on the installation of solar energy technology in residential areas.	0	17.2	21	25.8	44	34.0	25	23
5	I would like to receive practical training to install and operate solar PV technology so that it is easier to understand.	7	19.5	25	36.2	41	32.3	27	12.0

Notes: teacher (G); Student (M), 0% (1); 1-40% (2); 41-70% (3); 71-100% (4).

The majority of teachers (41%) and students (29%) had a moderate desire to have sufficient knowledge about the advantages of solar energy. Their desire to be exposed to various reliable sources to obtain information on the installation of solar energy technology in residential areas is also the majority at the intermediate level (teachers: 44%, students: 34%). The desire to receive practical training to install and operate solar PV technology so that it is more easily understood among teachers (41%) the majority is at the intermediate level, but at the low level among students (36.2%).

In conclusion, the desire of teachers and students to explore the use of solar energy and PV-Solar technology is still less encouraging. Therefore, it is necessary to expose them with sufficient knowledge and skills about solar energy and this PV-solar technology in order to increase their desire to explore the consumption of solar energy and this solar PV technology and indirectly contribute to energy sustainability.

The Relationship between the Level of Awareness on Energy Sustainability and Solar Energy with the Desire to Explore the use of Solar Energy and PV-solar Technology

Researchers argue that, the lack of enthusiasm of teachers and students in exploring the use of solar energy and PV-solar technology may be related to their level of awareness about energy efficiency and solar energy. Therefore, the researchers conducted a non-parametric equivalent test which is the Spearman correlation coefficient test to test the relationship between these two variables. The Spearman correlation coefficient test was used because the data for teacher and student awareness level variables on energy sustainability and solar energy were abnormally distributed making any inferential test involving these variables conducted using non-parametric equivalent test.

Research Question 7: Is there any significant relationship between the level of awareness about energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology?

H_0: There is no significant relationship between the level of awareness about energy and energy sustainability with the desire to explore the use of solar energy and PV-solar technology.
H_a: There is a significant relationship between the level of awareness about energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology.

Table 3.16 shows the correlation analysis of the level of awareness on energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology. Table 3.16 shows the analysis of the Spearman correlation coefficient test performed to determine the size and linear relationship between the level of awareness on energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology. The results of this Spearman correlation coefficient test found that there was a weak and significant positive linear relationship between the level of awareness about energy sustainability and solar energy with the desire to explore solar energy consumption and PV-solar technology [$r_s(698) = 0.418$, $p=0.00$; $p<0.05$] and thus reject the null hypothesis of H_0.

Table 3.16 Correlation analysis of the level of awareness on energy sustainability and solar energy with the desire to explore the use of solar energy and PV-solar technology

			Awareness	Desire to explore
Spearman's rho	Awareness	Correlation Coefficient	1.000	.418
		Sig. (2-tailed)	.	.000
		N	700	700
	The desire to explore	Correlation Coefficient	.418	1.000
		Sig. (2-tailed)	.000	.
		N	700	700

In conclusion, the higher the level of awareness about energy sustainability and solar energy, the higher the desire to explore the use of solar energy and PV-solar technology. Nevertheless, this analysis does not show significant evidence to state that the level of awareness about energy sustainability and solar energy influences the desire to explore the use of solar energy and PV-solar technology. The correlation between these two variables is likely to be influenced by external factors that teachers and students themselves may face in their environment such as lack of encouragement and exposure to energy sustainability and solar energy.

Discussion

Knowledge is a key element in the implementation of a T&L. The education sector should provide extensive exposure to students on career fields in the solar energy industry, while equipping students with sufficient skills and knowledge so that they can explore the diversity of career opportunities in the solar industry (Machuve & Mkenda, 2019; Abichandani et al., 2019). To run T&L of PV-Solar effectively, teachers need to have sufficient knowledge and skills. However, the analysis of teachers' knowledge scores on solar energy and PV-Solar technology shows that, teachers' knowledge is weak, same goes to the students' knowledge as well. Although there is a significant difference in the mean score of knowledge about solar energy and PV-solar between teachers and students where the analysis shows that teachers have higher knowledge about solar energy and PV-solar than students, but the level of knowledge of teachers and students is still weak about solar energy and this PV-Solar technology is of great concern.

Therefore, an action needs to be taken in order to overcome this matter such as developing any educational innovations, i.e. T&L framework or module that consist of teachers' training and students' learning. Therefore, exploration of the needs of teachers, students and the industry are important to ensure that future educational innovation initiatives are more effective, have a high impact and do not place any burden on teachers and students as stated in Theory of Change (MG Fullan, 1993; Fullan, 2006) but at the same time, able to meet the demand by the industry. The application of the concepts highlighted in Theory of Change was found to enable communities to identify individual activities that can be developed and coordinated in the structure of short- and medium -term goals, as well as long -term goals (Davenport et al., 2020; James, 2011)

Changing energy-saving behaviors towards sustainable consumption is one of the mitigation actions that help stabilize the level of greenhouse gases consisting of carbon dioxide gas that traps heat in the atmosphere (Hussain et al., 2021). Therefore, a survey of simple practices of energy sustainability was conducted on teachers and students to identify whether these practices are practiced or not in their daily lives. Among the simple energy sustainability practices included in the questionnaire were (1) use of electrical appliances with energy efficient technology, (2) use of electronic goods with energy efficient technology, (3) sensitivity to the value of monthly residential electricity bills, (4) the practice of energy saving measures, (5) the use of RE to generate electricity and (6) sensitivity to environmental issues and climate change caused by electricity generation. In conclusion, based on the percentage distribution of frequency of energy sustainability practices, it was found that these energy sustainability practices are more practiced among teachers than students.

Awareness of teachers and students about energy sustainability and solar energy respectively is low. Although the mean score of teachers' awareness level on energy sustainability is higher than that of students, it is still at a low level. This proves that, PDPC

PV-Solar is very necessary to be implemented in order to increase the awareness of teachers and students on energy sustainability and solar energy. Not only that, the desire of teachers and students to explore the use of solar energy and PV-Solar technology is also still at a moderate level. It is therefore necessary to expose them with sufficient knowledge and skills about solar energy and PV-solar technology in order to increase their desire to explore the use of solar energy and solar PV technology and indirectly contribute to energy sustainability.

The findings also show that the higher the level of awareness on energy sustainability and solar energy, the higher the desire to explore the use of solar energy and PV-solar technology. Nevertheless, this analysis does not show significant evidence to state that the level of awareness about energy sustainability and solar energy influences the desire to explore the use of solar energy and PV-solar technology. The correlation between these two variables is likely to be influenced by external factors that teachers and students themselves may face in their environment such as lack of encouragement and exposure to energy sustainability and solar energy. In conclusion, the overall analysis of the findings in this section proves the need to conduct PDPC PV-solar among students in order to improve their knowledge and skills on energy sustainability and PV-Solar while being able to apply that knowledge and skills in daily life.

Integration of ESD skills with STEM education is seen to be able to form an ideal PV–solar T&L strategy, but a gap is seen in terms of how this integration can be carried out in schools in Malaysia. Therefore, further study also should focus on the methods to integrate ESD and STEM education approaches. The integration of ESD and STEM is seen as very important because the four main branches of STEM can explain every phenomenon observed by each student in daily life and in their environment (Adam & Halim, 2019). STEM knowledge, along with a hands-on approach and open exploration, helps individuals understand problems, solve them creatively and innovatively, and apply that knowledge in a re-al-world context (KPM, 2018). Exposure to real -world situations encourages students to think in an open space of thought (Alam et al., 2016, Henriksen et al., 2017, Machuve & Mkenda, 2019). Learning through experience and observation helps motivate students to relate various branches of knowledge (Armitage et al., 2019; Didham & Ofei-Manu, 2020) are remain present in their thinking which then enhances their understanding of a thing learned (Alam et al., 2016 & Baran et al., 2019).

The empowerment of STEM education in ESD is believed to help achieve all the needs raised by the background of this study: (1) meet the human capital needs of the solar energy industry, (2) improve the lives and lifestyles of communities, (3) increase clean and safe energy use, and (4) provide quality and equitable education for all. This is in line with the goal of Malaysian STEM education: to meet the needs of the country in the future (KPM, 2018; Adam & Halim, 2019; Adnan et al., 2019). However, the problem here is how to integrate ESD with STEM T&L in designing a T&L approach for PV–solar studies. What are the most effective and frequently used ESD and STEM T&L strategies in schools? Therefore, further exploration towards existing ESD and STEM T&L elements helps streamline the empowerment and implementation of the proposed PV–solar T&L approach. This approach adapts existing T&L elements, and reduces the burden of teachers in accepting and implementing new educational initiatives.

Conclusion

This study identifies the level of knowledge of teachers and students about solar energy and PV-solar technology, simple energy conservation practices among teachers and students as well as their desire to explore the use of solar energy and PV-Solar technology. The overall analysis of the findings in this section proves the need to conduct PDPC PV-solar among students in order to improve their knowledge and skills on energy sustainability and PV-Solar while being able to apply that knowledge and skills in daily life. This is because, the findings shows that students' and teachers' knowledge on solar energy and PV-solar technology are weak and moderate level of desire to explore the use of solar energy and PV-solar technology. Therefore, further exploration of the needs of teachers, students and the industry need to be done in order to ensure that future educational innovation initiatives are more effective, have a high impact and do not place any burden on teachers and students. This study suggests that existing ESD and STEM approaches should be considered when formulating effective solar energy and PV–solar technology T&L strategies.

This study also contributes to the data on STEM Education and ESD in Malaysia indirectly. Future researchers can use this study data to support their study. In addition, this research data can also be used by the MOE to find alternatives to improve the quality of STEM education in Malaysia. The instruments for this study also can be adapted and used to conduct studies related to the scope of this research. This study proves the TRA as the findings shows that a person's behavior is determined by their intention to behave in such a way. The awareness among respondents correlates positively with their intention to explore more about solar energy and PV-technology. This shows a positive sign for future research to further develop this study in order to improve students' knowledge and skills on solar energy and PV-Solar technology in order to meet the needs of skilled manpower in the solar energy industry in the future.

Declarations

Availability of data and materials: The database used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interest

The authors declare that they have no competing interests.

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