ENHANCING ENERGY-EFFICIENT BUILDING LITERACY THROUGH EDUCATION AND SCHOOL ENVIRONMENT IDENTIFICATION AMONG VOCATIONAL HIGH SCHOOL STUDENTS

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ABSTRACT

The building sector contributes significantly to energy consumption; therefore, literacy regarding energy-efficient buildings needs to be strengthened from the school education stage onwards. This study aims to analyse improvements in understanding and the ability to identify energy-efficient buildings within the school environment. The study employed an educational-participatory approach with a single-group pre-test–post-test design. The research sample consisted of 30 Year 10 students from the Construction and Housing Technology Department at SMK Negeri 1 Percut Sei Tuan. The activities were carried out over four sessions, comprising the delivery of material, discussions, a pre-test, a post-test, and practical exercises in identifying aspects of natural lighting, ventilation, lighting usage, and user behaviour. Data were analysed using descriptive statistics and a paired-samples t-test. The results showed that the mean score increased from 46.80 to 80.43, with the pass rate rising from 0% to 86.67%. Meanwhile, the practical assessment achieved a mean score of 81.90 with a 100% pass rate. The paired-samples t-test revealed a significant difference ($p < 0.001$) between initial and final knowledge. The research findings indicate that education based on direct observation is effective in improving students' literacy and practical skills regarding the knowledge and identification of energy-efficient buildings.

Keywords: Energy-Efficient Buildings, Vocational Education, Participatory Learning, The School Environment.

1. INTRODUCTION

Buildings are closely linked to energy use and environmental sustainability (Husin et al., 2023). Energy in buildings is used to power lighting, air conditioning, ventilation, water supply and various other user activities (Aryani Widyakusuma, 2025; Azahar & Hariyanto, 2025). A report by the United Nations Environment Programme (2026) shows that the building and construction sector accounts for around 37 per cent of global carbon dioxide emissions and nearly 50 per cent of global material extraction. This highlights the need to improve energy efficiency from the planning stage through to the use and management of buildings.

In Indonesia, efforts to promote efficient and sustainable buildings have been supported by Regulation of the Minister of Public Works and

People's Housing No. 21 of 2021 on the Performance Assessment of Green Buildings. The technical guidelines for its implementation are set out in *Ministerial Circular PUPR Nomor 01/SE/M/*2022. Green building assessment covers several aspects, including site management, energy efficiency, water efficiency, indoor air quality, the use of environmentally friendly materials, waste management and wastewater management.

One of the key aspects of this concept is energy-efficient buildings. Energy-efficient buildings are influenced by the building's orientation, namely natural lighting, ventilation, the use of air-conditioning systems, and the behaviour of the building's occupants (Effendy & Silviana, 2021; Reztrie, 2023). Vocational secondary school students specialising in Construction and Housing Engineering constitute a relevant target group for energy-efficient building education. They are not only users of school buildings but are also being prepared to enter construction-related occupations that require technical competence, environmental awareness, and an understanding of sustainable development principles (Azahar, Hariyanto, et al., 2026; Azahar, Wibowo, et al., 2026). Contextual learning that connects subject content with actual conditions in the school environment can help students understand how energy-efficiency principles operate in everyday building use (Frigura-Iliasa et al., 2026; Lubis et al., 2025). Learning activities involving observation, discussion, and practical investigation also enable students to connect theoretical knowledge with observable conditions in their immediate environment (Azahar & Hariyanto, 2025; Nurhayati et al., 2025). Wang & Wang (2023) similarly found that observation- and inquiry-based energy learning can promote independent thinking, interdisciplinary understanding, and stronger mastery of energy-related concepts.

Despite this potential, students require learning experiences that move beyond the transmission of theoretical content and involve the direct identification of building conditions and energy-use practices. The school environment provides an accessible contextual learning resource through which students can examine natural lighting, ventilation, electrical equipment, cooling systems, and user behaviour. Such activities may strengthen both conceptual understanding and the practical ability to recognise opportunities for improving energy efficiency.

Accordingly, this community service activity aimed to evaluate the improvement in students' energy-efficient building literacy following a participatory educational programme and a school-environment identification exercise. Specifically, the activity aimed to: (1) improve students' understanding of the concepts and characteristics of energy-efficient buildings; (2) develop their ability to identify building conditions, energy-use practices, and user behaviours associated with energy efficiency; and (3) encourage awareness of practical energy-saving measures within the school environment. The activity was designed as an educational and preliminary identification exercise rather than as a formal assessment or certification of the school building.

2. PROBLEM AND RESEARCH QUESTIONS

Energy-efficient building principles need to be introduced through learning activities that connect technical knowledge with the conditions experienced by students in actual buildings. Although students in Construction and Housing Engineering programmes study various technical aspects of construction, classroom instruction alone may not provide sufficient opportunities to examine the relationship between building design, environmental conditions, energy use, and occupant behaviour. Limited direct observation may also restrict students' ability to recognise inefficient practices and formulate appropriate recommendations.

The school environment can function as a contextual learning resource because students can directly observe natural lighting, ventilation, lighting equipment, fans, air-conditioning systems, electrical appliances, and user behaviour. A participatory educational approach combining conceptual instruction, discussion, direct observation, and group reflection was therefore employed to strengthen students' knowledge and practical identification skills.

Based on this problem, the activity was guided by three research questions: (1) Is there a statistically significant improvement in students' understanding of energy-efficient buildings after participating in the educational programme and school-environment identification exercise? (2) To what extent do students' learning outcomes improve, as indicated by changes in the mean pre-test and post-test scores and the proportion of students achieving the minimum passing score? (3) Do students' practical skills in identifying energy-efficient building features meet or exceed the minimum passing score of 75? These questions guided the evaluation of changes in students' conceptual understanding, learning achievement, and practical identification skills following the educational activities.

3. LITERATURE REVIEW

Energy-efficient buildings are designed and operated to meet occupants' functional and comfort requirements whilst minimising unnecessary energy consumption. Their performance is influenced by the interaction between architectural design, building systems, environmental conditions, and operational practices. Passive design strategies, including building orientation, natural lighting, natural ventilation, solar shading, and thermal control, can reduce dependence on artificial lighting and mechanical cooling systems (Díaz-López et al., 2022). Research on educational buildings also indicates that spatial configuration, window design, building form, and other architectural parameters influence both energy consumption and occupants' thermal comfort (Alghamdi et al., 2022; Zhang & Bluyssen, 2021).

Nevertheless, building design alone does not determine actual energy performance. Occupants influence energy use through their interaction with windows, lighting, shading devices, fans, air-conditioning systems, and electrical appliances. Hax et al. (2022) demonstrated that differences in user behaviour, including the use of natural lighting, ventilation, and cooling systems, can produce different levels of energy consumption within an educational building. Similarly, Chen et al. (2021) and Xu et al. (2023) emphasised that building energy use reflects a dynamic interaction between physical systems, environmental conditions, occupant needs, and everyday operational decisions. Energy-efficient building education should therefore address both technical building features and the ways in which occupants use those features.

Understanding these interactions forms part of energy literacy. Energy literacy encompasses knowledge of energy sources and consumption, an understanding of their environmental consequences, attitudes towards responsible energy use, and the ability to make informed decisions about energy-related problems. Students with adequate energy literacy should be able not only to explain energy concepts but also to identify inefficient practices and propose appropriate energy-saving measures (Castañeda-Garza et al., 2025). Evidence from secondary school students shows that energy-saving behaviour is shaped by several interrelated factors, including knowledge, values, awareness, and behavioural intentions (Lee et al., 2022). Consequently, conceptual knowledge alone may not automatically result in responsible energy use. Energy education must also develop students' evaluative abilities, sense of responsibility, and willingness to take practical action (Nik Abdul Majid et al., 2025).

Energy-efficient building literacy is particularly relevant to vocational education because vocational students are being prepared to address technical and practical problems associated with their future occupations. Construction and Housing Engineering students require more than factual knowledge of building components. They also need the ability to assess the relationship between design decisions, building operation, environmental conditions, and user behaviour. Sustainability education in vocational settings should therefore connect disciplinary content with authentic problems that students can observe, discuss, and evaluate (Weijzen et al., 2024). Curriculum structure and teaching practices also influence the extent to which vocational students understand sustainability issues and apply them to occupational contexts (Chao, 2024).

The physical and social environment of a school can support this form of contextual learning. A whole-institution perspective views sustainability learning as a process embedded within the curriculum, the physical campus, organisational practices, and the participation of the school community (Holst, 2023). Classrooms, laboratories, workshops, and other school facilities provide observable examples of lighting, ventilation, thermal conditions, equipment use, and occupant practices. Students can therefore connect abstract energy concepts with conditions that they encounter during their daily activities. This connection is especially relevant in vocational education because the learning environment can be examined using knowledge and skills associated with the students' occupational field.

Contextual learning becomes more meaningful when students actively observe, investigate, discuss, and explain environmental conditions. The predict-observe-explain model, for example, allows students to compare their initial assumptions with observable evidence and construct explanations based on the results of their observations. Its application in energy education has been associated with improvements in independent thinking, interdisciplinary knowledge, and students' understanding of energy concepts (Wang & Wang, 2023). Place-based environmental learning similarly enables students to apply scientific and technical knowledge to problems found in their immediate surroundings (Gallay et al., 2021). Activities that involve identifying environmental problems and developing possible solutions can also strengthen energy literacy and critical thinking because students are required to interpret evidence rather than merely reproduce definitions (Merritt et al., 2024).

Participatory identification activities can further encourage students to recognise that building energy performance results from both physical and behavioural factors. Physical factors include natural lighting, openings, ventilation, solar protection, lighting systems, cooling equipment, and electrical appliances. Behavioural factors include opening or closing windows, switching lighting and cooling systems on or off, adjusting equipment, and disconnecting electrical appliances after use. Participatory building activities can help users identify existing building features, barriers to energy-saving behaviour, and opportunities for improvement based on their direct experience of using the space (Reimer-Watts et al., 2022). Such observations do not constitute a formal technical audit, but they provide an educational process through which students can develop preliminary identification and analytical skills.

Based on the reviewed literature, energy-efficient building literacy in this activity is conceptualised as the combination of conceptual understanding and practical identification skills. Conceptual understanding concerns students' knowledge of energy-efficient building principles, benefits, physical characteristics, and user responsibilities. Practical identification skills concern their ability to observe school-building conditions, recognise potentially inefficient practices, and formulate reasonable recommendations. Previous studies have examined energy literacy, building performance, occupant behaviour, and contextual sustainability education. However, the integration of these elements through direct school-environment identification remains less visible in vocational secondary education. This conceptual synthesis therefore provides the basis for assessing changes in students' understanding and their ability to identify energy-efficient building features following the participatory educational activities.

4. METHOD

a. Activity-based Approach

This activity employs an educational-participatory approach. The educational aspect is delivered through presentations, explanations of the material, question-and-answer sessions and discussions. The participatory aspect involves engaging pupils directly in observing and identifying the condition of the school buildings. The activity follows a one-group pre-test-post-test design, whereby all participants are given a test before receiving the material and are tested again once the entire series of activities has been completed.

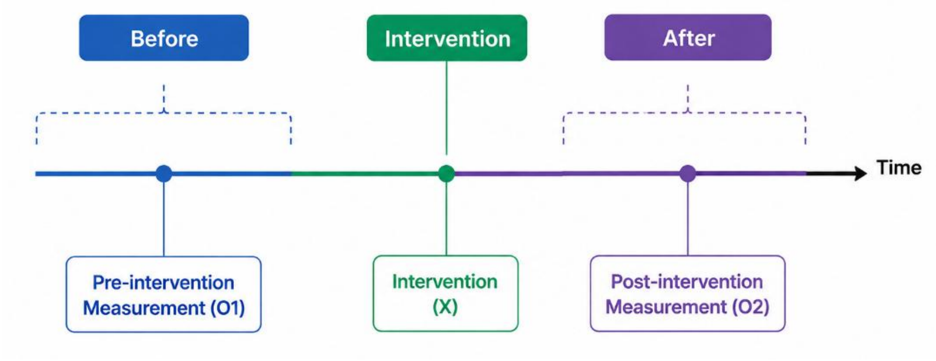

Figure 1. One-group pretest-posttest design

b. Venue and Participants

The event took place at SMK Negeri 1 Percut Sei Tuan from 19 to 22 August 2025. The participants were 30 Year 10 pupils from the Construction and Housing Technology vocational programme. Participants were selected in consultation with the head of the vocational programme and form tutors, taking into account the relevance of the material to the pupils' learning needs.

c. Stages of Implementation

This programme consists of four sessions, with the topics covered set out in Table 1 below:

Table 1. Materials used in the community service activities

No.	Code	Content
1.	Lesson 1	a. Definition of an energy-efficient building. b. The relationship between buildings and energy use.
2.	Lesson 2	a. Natural and artificial lighting. b. Natural ventilation and air conditioning. c. Building orientation and protection from the sun's heat.
3.	Lesson 3	a. The efficient use of lighting and electrical appliances. b. User behaviour in saving energy. c. A simple assessment of the condition of school buildings.

Table 2. Activities carried out over the course of four sessions

Meeting	Activities carried out	Expected outcomes
Session 1	a. Introduction to the activity b. Conducting the pre-test c. Topic 1	Data on pupils' initial understanding has been collected
Session 2	a. Topic 2 b. Topic 3	Pupils understand the characteristics of energy-efficient buildings
Session 3	Group-based practical activity to identify school-building conditions using the observation sheet	Pupils are able to relate the subject matter to real-life situations
Session 4	Presentation of observation findings, discussion of recommendations, reflection, and administration of the post-test	The results of the student evaluation and recommendations have been obtained

d. Research Instruments

The instruments used comprised: 1) Essay-type pre-test and post-test questions; 2) A rubric for assessing pupils' answers; 3) A school building observation sheet; 4) A group discussion record sheet; 5) Documentation of activities; 6) Field notes from the implementation team. The pre-test and post-test questions, as well as the practical tasks, were aligned with the material in Table 1, whilst assessment was based on the indicators in Tables 3 and 4:

Table 3. Assessment indicators for the pre-test and post-test

No.	Indicators
1.	Explaining the concept of energy-efficient buildings
2.	Explaining the benefits of energy-efficient buildings
3.	Identifying natural lighting and ventilation
4.	Identifying the use of electrical appliances
5.	To provide recommendations for the repair of school buildings

Table 4. Aspects and indicators observed

No.	Aspects observed	Observation indicators
1.	Natural lighting	The room receives plenty of sunlight during the day
2.	Natural ventilation	There are windows or openings that allow air to circulate
3.	Lamp	Use energy-saving light bulbs and switch them off when they are not needed
4.	Air conditioning	Air conditioning or fans are used as required
5.	Electrical equipment	The equipment is switched off or unplugged after use
6.	User behaviour	Pupils and teachers are practising energy-saving habits
7.	Energy monitoring	There is a system for recording or monitoring electricity usage

e. Data Analysis

The data were analysed using descriptive and inferential statistics. Descriptive analysis was carried out to describe changes in pupils' learning outcomes before and after participating in the energy-efficient building education programme. This analysis included: (1) the mean pre-test score; (2) the mean post-test score; (3) the difference between the mean pre-test and post-test scores; (4) the percentage of pupils who showed an improvement in their scores; and (5) the percentage of pupils achieving the required standard of understanding based on the Minimum Passing Criteria (KKM) of 75. In addition to average scores, the analysis also covers the minimum score, the maximum score, the number of students who achieved the required standard, and the overall achievement rate. Individual achievement is defined as a student obtaining a score of at least 75, whilst overall achievement is calculated based on the proportion of students who reached this threshold.

Next, a paired-samples t-test was used to determine whether there was a significant difference between the mean pretest and posttest scores within the same group of pupils. The hypotheses in this study were as follows: the null hypothesis states that there is no difference in the mean scores between the pretest and posttest, whilst the alternative hypothesis states that there is a significant difference in the mean scores. The test decision was based on a significance level of 5 per cent. If $p < 0.05$, the null hypothesis is rejected, meaning that the increase in scores is statistically significant. The practical test results were analysed using descriptive statistics, including the mean score, minimum score, maximum score, number of students who achieved the required standard, and the percentage of students who achieved the required standard. Next, a one-sample t-test was used to determine whether the students' average practical scores differed significantly from, and were higher than, the minimum passing mark of 75. In this test, the minimum passing mark was used as the benchmark. If the p-value was less than 0.05 and the average practical score was above 75, the students' practical achievement was deemed to have significantly exceeded the minimum passing standard.

5. RESEARCH FINDINGS AND DISCUSSION

a. Implementation of Energy-Efficient Building Education

The educational programme on energy-efficient buildings was conducted over four sessions and attended by 30 Year 10 students at SMK Negeri 1 Percut Sei Tuan. The entire programme comprised a pre-test, delivery of teaching materials, discussions, practical exercises in identifying features of the school building, group presentations, and a post-test. During the first session, the students completed an essay-style pre-test to assess their prior knowledge of energy-efficient buildings. Based on their initial answers, some students were already familiar with energy-saving measures such as switching off lights and air conditioning. However, their understanding of the relationship between building design, natural lighting, ventilation, building orientation and protection against solar heat was still (limited/quite varied).

Figure 2. Presentation on Energy-Efficient Buildings

The second session focused on introducing the concept of energy-efficient buildings. The material was presented using a presentation supported by images and examples of its application in buildings. During the session, pupils were given the opportunity to relate the material to classrooms, laboratories, workshops, the library and other facilities at the school. In the third session, the students were divided into six groups to identify the condition of the school buildings. Each group observed the buildings in each department within the school, then recorded the conditions regarding lighting, ventilation, protection against heat, the use of lighting, the use of air conditioning or fans, and the behaviour of building users. The fourth session was used to present the results of the observations. Each group outlined the strengths, weaknesses and recommendations for improvement based on the conditions they had identified. Following the presentation and discussion session, the pupils completed a post-test as a final assessment.

b. Improving Students' Understanding

To assess the pupils' understanding, pre-test and post-test questions were set as part of this activity to gauge the understanding and knowledge acquired during the learning process.

Figure 3. Administration of the pre-test and post-test

In the pre-test phase, the highest score was only 63, meaning that no pupils had yet met the pass mark of 75. The pupils' average score before the training was 46.80; after the activity, 26 out of 30 pupils had achieved the pass mark, with an average score of 80.43. There were still four pupils with a post-test score of 71 who required further support with their learning. The pre-test and post-test results can be seen in the table:

Table 5. Results of the pre-test and post-test for pupils

Indicators	Pre-test	Post-test	Improvement
Minimum value	25	71	-
Maximum value	63	95	-
Average value	46.80	80.43	33,63
Number of pupils who have completed the course	0	26 people	26 people
Percentage of completion (%)	0	86.67	86.67

Table 6. Results of the t-test

Comparison	Average difference	t	df	Sig. (2-tailed)	Decision
Posttest-pretest	33.63	13.751	29	<0,001	H_0 is rejected

The results of the paired-samples t-test showed a value of ($t(29) = 13.751$) with a significance level of ($p < 0.001$). As this significance level is less than $\alpha = 0.05$, H_0 is rejected and H_1 is accepted. These results indicate that there is a significant difference in means between the pre-test and post-test scores, with an increase in the mean score of 33.63 points. This increase suggests that education through presentations, discussions and practical exercises in identifying features of the school environment can help pupils understand the concept of energy-efficient buildings. Pupils not only received theoretical explanations but also observed first-hand the condition of the buildings they use every day. These results are consistent with observation- and inquiry-based learning about energy, which provides pupils with the opportunity to predict, observe, explain and relate energy concepts to their everyday experiences.

c. Pupils' Ability to Identify School Buildings

To identify the school buildings, the pupils were divided into six groups, each comprising five members. The buildings identified varied according to the breakdown shown in Table 7:

Table 7. Location in the identification of energy-efficient buildings

No.	Group	Buildings
1.	A	Geomatics Engineering
2.	B	Electrical Power Network Engineering
3.	C	Television Programme Production and Broadcasting
4.	D	Computer Engineering and Networking
5.	E	Motorcycle Technology and Business
6.	F	Audio-Visual Technology

Following the allocation, the pupils were given 30 minutes to identify the buildings according to their assigned groups. After their observations, the pupils gave a 10-minute group presentation to the class, followed by a question-and-answer session amongst the pupils.

Figure 4. Presentation of the Group's Observation Results

The results of the practical assessment in Table 6 show that pupils' marks ranged from 75 to 88, with an average mark of 81.90. Based on the pass mark of 75, all 30 pupils were deemed to have passed, resulting in a pass rate of 100 per cent. These results indicate that pupils are able to identify the application of energy-saving principles within the school environment. The aspects assessed that have contributed to energy savings include adequate natural lighting, the provision of ventilation, and the presence of greenery in each department, which helps to naturally cool the school grounds for pupils.

Table 8. Results of the assessment of students' practical work

Indicators	Practical Assessment	Description
Minimum value	75	-
Maximum value	88	-
Average value	81.90	Good category
Number of pupils who have completed the course	30 people	All pupils have completed the course
Achievement rate (%)	100	The target has been met

The results of the pupils' assessment of the energy-efficient school building are shown below:

Table 9. Results of observations from the fieldwork activities

Aspects	Conditions found	Recommendations
Natural lighting	The pupils felt that the amount of natural light entering the classroom during the day was not optimal.	Open the windows as wide as possible, clean the windows, and adjust the curtains so that they do not block the light.
Natural ventilation	Pupils feel that the windows are not being used to their full potential in the cross-ventilation system, which leads to the use of air conditioning and fans in the classroom	Optimise existing window ventilation by ensuring that the windows can be opened.
Use of lights	Pupils criticised the wasteful use of lights, which are constantly left on in the classroom, and the habit of not switching them off.	Switching the lights on at the right time and switching them off when pupils are not in the room.
Use of air conditioning/fans	The pupils felt that the air conditioning and fans were used as required.	Use air conditioning and fans as required.
User behaviour	The pupils felt that their behaviour did not yet promote energy saving.	Running energy-saving campaigns, putting up reminder posters, and providing regular

	feedback on energy usage behaviour.

This identification exercise helps pupils understand that energy saving is influenced by two factors. The first factor relates to the physical condition and systems of the building, such as openings, lighting, ventilation, sunshades, lamps and air-conditioning systems. The second factor relates to users' behaviour when operating the building's facilities.

d. The Role of Education in Improving Pupils' Literacy

The results of the analysis show that education on energy-efficient buildings can significantly improve students' understanding; a learning approach that combines the presentation of concepts, discussion, observation of real-world environments and experience-based assessment is more effective than learning that focuses solely on the presentation of theory. This improved understanding indicates a shift in perspective regarding the relationship between building design, energy consumption and user behaviour. A study by Widyastuti et al. (2020) This demonstrates that hands-on energy education programmes are effective in enhancing pupils' understanding, as they are given the opportunity to link abstract concepts about energy to the phenomena they encounter in their daily lives.

In the context of energy-efficient buildings, the students' increased understanding in this study was influenced by their direct involvement in observing the conditions of the school building. The students learnt about concepts such as natural lighting, cross-ventilation and building orientation, and assessed how these principles were applied in their own school environment. This approach enabled the students to make connections between building design theory and real-world conditions, thereby making the concept of energy efficiency easier to understand. Research by Gosselin et al. (2016) which reveals that place-based learning can enhance understanding of energy, as pupils use familiar places as objects of analysis. School buildings serve as an effective learning medium because pupils interact with these spaces every day; consequently, an assessment of lighting conditions, ventilation and energy use is directly relevant to their experiences.

In addition to the knowledge aspect, the improvement in learning outcomes also suggests that education on energy-efficient buildings can serve as an initial strategy for building energy literacy among the younger generation. According to Nik Abdul Majid et al. (2025), Energy literacy encompasses not only an understanding of energy sources and usage, but also an individual's ability to make decisions that promote energy efficiency. Therefore, the building identification activity in this study is of great importance as it encourages pupils to think critically about energy issues in their local environment.

e. The Role of Practice-Based Learning in Developing the Ability to Identify Energy-Efficient Buildings

Pupils' ability to identify the condition of buildings demonstrates that the learning process does not stop at enhancing cognitive aspects, but extends to the ability to analyse the built environment. Hands-on observation activities provide pupils with the opportunity to evaluate the relationship between a building's characteristics and its potential energy consumption. This ability is a key aspect of sustainable building education, as energy efficiency in buildings is determined not only by the technology used, but also by users' understanding of the characteristics of the space (Cole, 2019; Shen et al., 2012). Research by Khoirunnisa et al. (2023) explains that the successful implementation of energy-efficient buildings is heavily influenced by users' ability to understand and operate the building's elements correctly. Even well-designed buildings can still suffer from energy wastage if users do not understand how to make optimal use of natural lighting, ventilation and cooling systems.

Research by Patil dan Tanavade (2024) It also shows that involving pupils in the identification of simple energy-related issues within educational facilities can improve their ability to observe the factors contributing to energy consumption. Through this identification process, pupils begin to understand that energy consumption results from the interaction between the technical aspects of a building and the behaviour of its users. In this study, the pupils identified several areas for improvement, such as optimising natural lighting, managing ventilation, and electricity usage habits. This demonstrates that pupils are able to identify energy-related issues in context, rather than simply on the basis of definitions learnt during lessons. This ability is an important indicator that learning has reached the level of analytical thinking. According to Brychkov et al. (Brychkov et al., 2023), Sustainable learning in schools needs to shift from a knowledge-based approach towards action-based learning, namely learning that develops the ability to evaluate environmental issues and propose solutions. The practical approach adopted in this study has implemented this principle, as pupils not only received information about energy-efficient buildings, but also carried out evaluations and drew up recommendations for improvements.

f. The Relationship between Building Factors and User Behaviour in Energy Saving

The results of the student survey show that understanding of energy-efficient buildings cannot be separated from user behaviour. These findings indicate that energy efficiency is the result of a combination of the quality of a building's design and how people use the facilities. This concept is consistent with the building-user interaction approach, namely the view that a building's energy performance is influenced by the interaction between the building systems and human behaviour. Research by Hax et al. (2022) shows that user behaviour can contribute significantly to variations in energy consumption in educational buildings. Even buildings with good energy-efficiency systems may experience an increase in consumption if users have inappropriate energy-usage habits.

In a school context, simple actions such as switching off lights when a room is not in use, making the most of natural light, and regulating the use of air conditioning are key factors in the success of energy conservation. Research by Soares et al. (2015) It emphasises that educational interventions targeting user behaviour are one of the effective, low-cost strategies for reducing energy consumption in educational buildings. However, this study also shows that behavioural change requires an ongoing process. A one-off educational initiative may raise initial awareness, but follow-up strategies such as school energy campaigns, the installation of reminder signs, monitoring of energy consumption, and the involvement of the school community are necessary to ensure that behavioural changes are sustained in the long term. This is reinforced by Kurnia et al. (2024) which states that school-based energy efficiency programmes will be more effective if implemented on an ongoing basis, involving pupils, teachers and facility managers.

6. CONCLUSION

Educational activities and environmental assessment within the school demonstrated an improvement in energy-efficient building literacy amongst Year 10 students in the Construction and Housing Engineering programme. The students' average score rose from 46.80 in the pre-test to 80.43 in the post-test, representing an increase of 33.63 points. The pass rate rose from 0% to 86.67%. The results of the paired-samples t-test indicate that the difference between the pre-test and post-test scores is statistically significant ($p<0.001$). The results of the one-sample t-test showed that the difference was statistically significant ($p<0.001$). These findings indicate that participatory educational activities combining the delivery of material, discussion and direct observation of the school environment can improve pupils' understanding of the principles of energy-efficient buildings. The students' practical skills showed good results, with an average practical mark of 81.90 and a 100 per cent pass rate. Consequently, this activity can enhance conceptual knowledge and develop students' ability to identify energy-efficient buildings. Based on these findings, vocational schools are encouraged to integrate energy-efficient building education into contextual and practice-based learning, particularly within construction-related programmes. Future activities should combine classroom instruction, direct observation of school facilities, structured discussion, and simple measurements of lighting, temperature, ventilation, and electricity use. Further research should involve larger and more diverse samples, include a control or comparison group, conduct follow-up assessments, and examine changes in students' attitudes and actual energy-saving behaviour using validated instruments and objective building-performance data.

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