INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

Effectiveness of Computational Thinking Integrated Module in Enhancing Learning Gains in Renewable Energy Education Among Young Learners

Heerashini Subramaniam[1*], Dennis Andrew Lajium[2]

Universiti Malaysia Sabah

DOI: https://doi.org/10.47772/IJRISS.2026.100500641

Received: 12 May 2026; Accepted: 18 May 2026; Published: 10 June 2026

ABSTRACT

This study explored the effectiveness of a Computational Thinking Module (CT-Module) in improving computational thinking skills and renewable energy awareness among primary school students in Sabah, Malaysia. In today's rapidly developing technological era, students are expected to master 21st-century skills such as critical thinking, problem-solving, and environmental awareness. Computational thinking (CT), which includes skills such as decomposition, pattern recognition, abstraction, and algorithmic thinking, has become increasingly important in science and STEM education. At the same time, renewable energy education is essential in developing environmentally responsible future generations. However, limited research has focused on integrating computational thinking with renewable energy learning among young learners in Malaysian primary schools.

This study was guided by Piaget's Constructivism Theory and the Computational Theory of Mind. A structured CT-Module was developed using the ADDIE instructional design model. The module combined both plugged and unplugged learning activities related to renewable energy concepts, energy conservation, and computational thinking practices. A quantitative quasi-experimental research design involving treatment and control groups was employed. Year 4 students were selected using matched-pair sampling techniques. Data were collected through computational thinking pre-post tests and renewable energy awareness tests. The data were analysed using descriptive statistics, independent sample t-tests and MANOVA.

The findings showed that students who used the CT-Module demonstrated significantly higher improvement in computational thinking skills and renewable energy awareness compared to students who received conventional instruction. The treatment group achieved greater learning gains. The study suggests that integrating computational thinking into renewable energy education can effectively strengthen students' higher-order thinking skills, problem-solving abilities, and environmental awareness. The CT-Module also serves as a practical teaching resource that can support interdisciplinary STEM and sustainability education in Malaysian primary science classrooms.

INTRODUCTION

Computational thinking pervasively emerging in STEM education. Being one of the fundamental interdisciplinary elements in developing thinking skills and fostering problem-solving skills among students, it has ubiquitously been and is being used in curricular to empower a monolithic intelligent generation in the future. Rapid growth in advancement of the Fourth Industrial Revolution (4IR) has required critical skills for 21st century students. Equipping students with these skills has become paramount as they will face problem solving situations frequently. Computational thinking (CT) is an epochal skill involving problem solving aspects such as decomposition, abstraction, pattern recognition and algorithmic thinking, has emanated as a stepping stone for cultivating innovation and prepare students to face real world challenges efficiently.

On the other hand, sustainable environmental education which also requires interdisciplinary thought processes in science education that pose difficulty to students can be taught by engaging computational approach. Simultaneously, the growing environmental crisis has highlighted the need for computational thinking approach surrounding innovative ideas and techniques to solve them. Simultaneously, the growing environmental crisis has highlighted the need for computational thinking approach surrounding innovative ideas and techniques to solve them. CT particularly, is growing in tandem in problem solving as it involves step by step process to approach the final solution. It was first introduced by Papert in 1980 and grown rapidly where Jeanette Wing defined CT as essential skill for every student and should be instilled into every child's analytical ability (Lodi & Martini, 2021). Sustainable environmental problems demand interdisciplinary process as solution which impacts both students and public. Learning about environmental problems involves students actively in different stages such as getting to address the problems, breaking down the problems, giving importance to certain things without compromising other aspects and so on. Thus, computational thinking which is an interdisciplinary thinking process involves key aspects to problem solving which are decomposition, abstraction, pattern recognition and algorithm. Computational thinking presage in variety of topics around the world, yet it is weakly integrated nor commonly used in classroom (Lyon & Magana, 2020). Computational thinking has a great ability to be taught as stand-alone subject or integrated in multifaceted disciplinary such as in science. Computational thinking can be used as a mediator to navigate scientific and logical process while maintaining environmental awareness and emotions using proper teaching materials and method. Easterbrook (2014) argues that technology, human behaviour and environmental impacts are correlated in driving realistic environmental solutions. The interdisciplinary nature of CT paves its way for elementary students to make connections throughout environmental studies. For instance, learning about energy sources can be taught by using decomposition or electricity production can be learned by using algorithms. In contrast, research gaps still exist in combining CT with environmental studies (Lyon & J. Magana, 2020). This is because students' inability to think systematically is a major weakness and lack of knowledge in STEM is a major limiting factor in tackling environmental dilemmas such as sustainable development, responsible consumption and productions, pollution, environmental health and renewable energy (Bakala et al., 2021; Su et al., 2024; Tang et al., 2020). A survey by Gunckel et al (2022) posit there are still some vacuities exists in combining computational thinking with environmental studies, but also particularly encompass the interdisciplinary theme if sustainability with computational complexity.

In Malaysia, the renewable energy knowledge gap is particularly alarming. From switching off classroom fans to turning off charger at home, energy plays important role, yet significant loops remain in encouraging students understanding about energy. In parallel with increased awareness and the need to foster sustainable education among students, high order thinking skills involving computational thinking, advanced technologies, and applications should be vastly integrated to provide an innovative playground for the younger generation to explore environmental problems, whilst educators are expected to prepare a base for them in these tasks using various problem-solving skills like computational thinking. Malaysian primary science syllabus has included environmental education through textbooks and activities. However, it can be still harnessed effectively by combining computational thinking to emphasize real life world problems, exploration, simple innovations and more. Implementation of CT has been part of the new Standard-Based Curriculum for Primary School (KSSR), initiated in January 2017 (Abas, 2016). There has been also proven that students can start learning CT as early as primary school (Ismail et al.,2016; Lye and Koh, 2014; Rijke et al., 2018). However, a study by (Ung et al., 2018) revealed teachers have poor understanding of CT, yet they are interested and needed more resources on applying CT in classrooms (Senin, 2019). Osman et al (2006) also stated science teachers needs more support in designing and planning their instruction in classroom. This indicates a structured resource in form of learning tool is fundamental to aid teachers in implementing computational thinking. As the consequences, many students stay unaware of the negative impacts of energy overconsumption particularly on non-renewable energy depletion on global ecosystems and are ill-equipped to engage in environmental initiatives.

The research aims to find out the effectiveness of computational module integration in primary science curriculum that emphasizes renewable energy among level 2 students. It intends to understand the different activities which can be compiled under one module to be integrated effectively among students to increase their awareness and participation in real life environmental problems thus creating an innovative generation for better world. A quantitative method will be used to gain in-depth insight into improvement of students in computational thinking related to sustainable education. This data will be contextualized with a view of recent literature views and gaps existing in Malaysian Primary Science Curriculum regarding computational thinking with sustainable education.

Research Objectives

- To determine the effectiveness of computational thinking module in improving computational thinking among primary science students.
- To determine the effectiveness of computational thinking module in increasing renewable energy awareness among primary science students.

Hypothesis

Ho 1: There is no significant difference in increase of computational thinking skills between control and treatment group.

Ho 2: There is no significant difference in increase of renewable energy awareness between control and treatment group.

Computational Thinking for Young Learners

CT is a fundamental skill rooted in problem-solving which has emerged as one of the critical skill to be mastered by young learners. It is a domain-general ability that lifts overall cognitive functioning and general school readiness for complex concept learning (Yang et al., 2023). Engaging in CT through activities like pattern recognition, abstraction, decomposition and algorithm helps develop high order cognitive processes, including information retaining and manipulation, inhibition that comprises self-control and attention and cognitive flexibility to revamp ideas and solve problems alternatively (Zeng et al.,2023a ; Mills et al., 2021). Besides, CT associated with active regulation of attention and behaviour, strongly impacting early success in literacy and science learning (Lee et al., 2019). Ogegbo & Ram-narain (2022) also supported the notion where CT deploys inquiry-based learning which requires students to construct their knowledge on their own, increasing learning retention, behavioural change and so on. In this context, there are fewer studies deployed to investigate CT learning among young learners. Hence, there is critical need for more comprehensive research in low-resourced socioeconomically disadvantaged background such as rural areas. As CT is mainly taught as programming and plugged in, it remains challenging for many rural and remote areas. Thus, unplugged teaching is considered efficient to deliver CT in multidisciplinary subjects. CT-unplugged teaching can be done in various ways including games, worksheets, projects and modules.

In the other hand, there is an imbalance in research that focuses primarily young learners. In this context, there is a significant research gap exist in studies involving young learners (ages 6-10). A meta-analysis by (Cheng et al., 2026) shows many research focuses on middle aged school learners, leaving the developmental trajectories and effectiveness of early intervention for elementary learners (age 6-10) under-researched. There is a need for research that extends to young learners to investigate the effectiveness of CT and its impact on students. Hence, this study targets primary school learners (10 years old) as they are still in concrete cognitive phase which might be difficult to grasp abstract concepts. A CT module that comprises computational thinking as an introduction to abstract concepts helps them to involve directly and engage actively in classroom.

Computational Thinking In Environmental Education Among Young Learners

Environmental Sustainability (ES) learning requires complex problem solving and decision making which takes place in diverse social and cultural contexts. These sociocultural impacts take place in science learning. Thus, deep understanding should be specifically considered when unveiling interdisciplinary topics related to ES learning. A scientifically literate society can grasp the mechanisms involved in environmental issues effectively and further will indulge in the solution for the problems. Hence, it is important for young learners to explore the problems around their environment. A contextualised learning is crucial for students to apply computational thinking in solving environmental problems. According to (Yang et al., 2022), localized learning content (LLC) which uses problems and scenarios relevant to children’s specific life experiences and cultural background can significantly elevate their motivation and CT skills. Understanding how students conceptualize computational thinking as a creative and problem-solving tool, determining their confidence in applying computational skills for inquiry, and investigating how CT cultivates critical thinking and innovation can provide deeper insights for effectiveness of integrating CT in environmental studies among young learners, yet it remains an overlooked methodology for young learners in many regions. While existing research has explored students; attitudes towards CT, fewer studies investigated their perspective on CT as a motivational tool for creativity, collaboration and real-world problem solving particularly in environmental studies. As these aspects of CT inherently tied to higher order thinking and challenging, there is a need for appropriate pedagogy for introducing them with CT. Hence, this study explores how CT module provides deep insights on bringing positive outcome in renewable energy awareness among young learners.

Renewable Energy Awareness in Malaysia

The National Philosophy of Education outlines holistic development of individuals which is achieved through integrated learning that emphasizes intellectual and spiritual growth, focusing students' ability to contribute to societal betterment. Besides, 'MyDIGITAL' and the Malaysian Economic Blueprint 2021 underpinned the commitment to preparing a future ready workforce intertwined with computational capabilities to drive a digital economy. Hence, local research demonstrates successful implementation of CT into sustainability educations. For instance, integrating STEM approaches across primary education have been proven to increase energy literacy to a high level, shifting student values from a personal perspective to a global one regarding resource conservation (Bharathi et al., 2022). Furthermore, the "McodE Module" which was developed to study heat concept in solar projects has significantly improved students' engagement and understanding in STEM through CT skills (Jaya et al., 2025). Also, the Solar -Powered IoT Hydrophonic Modules which was implemented to connect STEM elements parallel to SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action) embedded use of microcontrollers, environmental sensors, solar energy components and cloud based monitoring platforms to create accessible agricultural solution had positive impact on students where 90% overall students rated "excellent" or "good" experiences through their practical sessions besides their technical skills and positive attitudes towards environment increased drastically (Maizahtulakma et al.,2025). Besides, Zakaria et al. (2024) in her empirical research has supported the notion where the interactive mobile applications have proven effective, with over 98% of 9-year-old students improved their understanding and awareness of renewable energy. Despite the successes of these modules, projects and applications, students particularly in primary level still struggle with the synthesis of conceptual energy knowledge and algorithmic thinking in high complexity scenarios. The field of concurrently cultivating CT and environmental awareness scarcely under investigated with critical lack of empirical evidence on these two domains grow together. Hence, this study aims to address this gap by combining CT and renewable energy into simple introductory module to 10 years old students where their syllabus contains energy topic which comprises energy transfer, renewable energy, how energy created and sustainable energy The module will be an induction for CT concepts through energy literacy for students before they seek deeper knowledge in the upcoming years. This is significant as CT is not taught as stand-alone subject or concept in Malaysian Primary Education Syllabus, as it is embedded in multidisciplinary subjects. By getting to know basic concepts of CT concepts, students will be more prepared and able to understand abstract concepts systematically.

Developing structured, contextually aligned modules is crucial for solving current lack of CT skills among students. By framing CT as cognitive mediator though which sustainability presents as core element, educators can fulfil national policy while elevating students' cognitive ability to tackle 21st century environmental challenges. The use of structured pedagogical modules has emerged as a primary solution for addressing the deficit in Computational Thinking (CT) skills involving sustainable education.

METHODOLOGY

This research was conducted to investigate the effectiveness of CT-Module in increasing computational thinking skills and renewable energy in science lesson among primary level 2 students. Hence, this study deploys quantitative research which used quasi experimental design. A computational thinking learning module (CT - Module) was developed using ADDIE model to evaluate its effectiveness in increasing computational thinking skills and renewable energy awareness among students. There were five phases involved, Phase 1: Analysis, Phase 2: Design, Phase 3: Development, Phase 4: Implementation and Phase 5: Evaluation. Permission to conduct the research for data collection obtained from Ministry of Education and Sabah State Education Department. This study was intended that a structured, validated module could be handed as teaching and learning aid to guide primary school teachers once the module had proven to be effective in harnessing primary school science children's computational thinking in environmental sustainability particularly on energy literacy as well as increasing their awareness about global environmental issues. The effectiveness of the validated module in improving children's computational thinking and environmental sustainability was evaluated before implementation. The independent variable for the research is the learning method while dependent variable is computational thinking (CT) skills and renewable energy awareness (REA). All the samples were selected using matched pair random sampling using G-Power software from the year 4 population. The control group's learning was conventional method whereas treatment group used CT-Module to learn renewable energy. While computational thinking skills measured using pre-post-test, renewable energy awareness was measured using simple end of unit test called Renewable Energy Awareness test. As this is a quantitative design research, the data collected analysed using MANOVA (IV: Learning method, DV: Improvement in computational Thinking and Renewable Energy Awareness), independent sample t-test (IV: Learning method, DV: Improvement in computational Thinking and Renewable Energy Awareness), and descriptive statistics.

Computational Thinking Module (CT-Module)

The effectiveness of teaching and learning lies on meticulous selection of reasonable teaching and learning materials. Among the increasingly popular resources emerging in education nowadays, modular strategy has still been at the top selection because of its diversity which can be applied in various methods such as distance learning, e-learning, self-guided learning, teaching aids in classroom and more. This study focused on evaluation of instructional material in the form of module among 10-year-old students. A well planned, designed instructional module is essential for the successful learning outcome of a subject. The CT-module is the main instrument that will be used for students in treatment group to teach computational thinking in renewable energy lesson. The design of module is based on Constructivism Learning Theory and Computational Theory of Mind. The module was built based on ADDIE model developed by Dick and Carry (1996) for building learning systems. The term ADDIE is an acronym for Analysis, Design, Development, Implementation and Evaluation. From the acronym ADDIE, it signifies the application of module at five levels which propel the practice of developing module. Each of these elements or levels doesn't need to comply a sequential pattern, rather, the levels involved informs one another in a design system (Suratnu, 2023).

The module will be used to teach Energy topic with the integration of computational thinking and environmental sustainability awareness. Table 1 shows the details and steps involved during each phase.

Table 1: Module Activities Breakdown

Phase	Topic	Activity
1	Introduction to energy	Renewable energy and non-renewable energy Definition, examples
2	Clean energy	Concept Examples
3	Saving Energy	Examples of electric saving at home and school
4	Introduction to computational thinking	Decomposition Pattern Recognition Abstraction Algorithm Examples Questions and Discussion
5	Problem Solving Activity	Environmental scenario DIY projects Presentations
6	Group Activity	Renewable energy DIY projects

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

Population and Sampling Frame

The population consist of 192 year 4 students in the selected primary school. The sampling frame was generated using official lists from school's administration. Researcher sets few criteria for being eligible to this research. Only students who fulfilled these criteria were maintained in this research which are (1) Physically and mentally fit: As students cognitive skills plays important role in this research, therefore researcher considered this as the main criteria, (2) Achievement level from band 3-5. It is crucial for students to understand concepts as computational thinking considered new, hence, band 3-5 achievement level is sufficient to be involved in the research. Besides, this is to ensure medium and excellent students randomised to make generalization at the end of the research, (3) Learning Science in Malay, to ensure there is no dual language questions and misunderstandings among them. Besides, it is also to maintain validity and reliability of this study and avoid sampling bias. These criteria were selected because they are highly correlated with academic and cognitive performance among primary level students. Also, the procedure aligns with MOE research ethics, particularly in ensuring voluntary participation and ensuring student welfare. Using G Power software, researcher calculated total samples needed for two-way Manova analysis. According to the software, 78 samples need to be selected. Matching was conducted using nearest-neighbour approach to ensure each pair comprised equally with closely similar attributes.

Data Collection

Since this is quantitative research, the researcher used pre-post-test to gather data from samples. The instruments were the most suitable tool for comparing the achievement of two different groups in practicing and applying computational thinking. The first objective, which is increasing students computational thinking skills tested for effectiveness using pre-post-test. The test was reviewed for validity by three experts (2 science teachers, 1 lecturer).

A simple end of learning test which focuses on renewable energy awareness knowledge was done among both groups. There were 30 questions consisting of REA definition, sources, electricity production and energy saving. Then, students' response were collected as marks and analysed. The test undergoes face and content validation by three experts (2 lecturer, one teacher). The knowledge test has received good comments and validation from experts.

Data Analysis

The data obtained from the research instruments were analysed using IBM SPPS. Descriptive statistics such as mean, standard deviation, frequency and percentage to summarise and describe students' computational thinking skills and renewable energy awareness scores. An independent samples t-test was deployed to investigate whether there is significance difference in computational thinking scores between control and treatment group. Meanwhile, Multivariate Analysis of Variance (MANOVA) was conducted to investigate overall effect of CT-Module on two dependent variables simultaneously, which is computational thinking skills and renewable energy awareness.

RESULTS

Effectiveness of Computational Thinking Module in Increasing Computational Thinking Skills among Students

The analysis addresses the first research question which is:

To determine the effectiveness of computational thinking module in increasing computational thinking among primary science students.

In conjunction with the research questions, researcher developed hypotheses:

H_1: There is significant difference in increase of computational thinking skills between control and treatment group.

H_o: There is no significant difference in increase of computational thinking skills between control and treatment group.

Descriptive Statistics of Computational Thinking Module Effectiveness by Pre-Post Test

A descriptive analysis was conducted to examine students' computational thinking scores in both the treatment and control groups before and after the intervention. The analysis focused on the mean scores and standard deviations to provide an overview of students' performance. Table 2 shows descriptive statistics for computational thinking scores.

Table 2: Descriptive Statistics for Computational Thinking Scores

Test	Teaching Method	N	Mean	SD
Pre-Test	Control	39	22.69	10.222
	Treatment	39	16.87	6.225
Post-Test	Control	39	26.62	10.341
	Treatment	39	60.62	9.016

The descriptive results show that students in the control group initially recorded higher computational thinking scores during the pre-test phase (M = 22.69, SD = 10.222) compared to students in the treatment group (M = 16.87, SD = 6.225). This suggests that the control group began the study with a slightly stronger level of computational thinking skills.

After the intervention, improvements were observed in both groups. However, the increase in scores was substantially greater among students in the treatment group. The treatment group achieved a post-test mean score of 60.62 (SD = 9.016), while the control group recorded a mean score of 26.62 (SD = 10.341).

The findings indicate that students who participated in learning through the CT Module demonstrated a remarkable improvement in computational thinking skills compared to students who experienced conventional teaching methods. Although the control group showed a small increase in scores after the intervention period, the improvement was much lower than that observed in the treatment group. In addition, the standard deviations for both groups suggest that students' scores were moderately spread around the mean. Overall, the descriptive analysis provides clear preliminary evidence that the CT Module positively influenced students' computational thinking skills.

Independent Samples t-Test Analysis for Computational Thinking Skills

An independent samples t-test was conducted to examine whether there were differences in computational thinking skills between students in the treatment group and the control group before and after the intervention. This analysis was carried out to determine the effectiveness of the CT Module in improving students' computational thinking skills. Table 3 shows independent sample t-test result.

Table 3: Independent Sample T-Test Result for Computational Thinking Pre Post Test

Test Phase	Levene's Test F	Sig.	t	df	p	Mean Difference	95% CI Lower	95% CI Upper	Interpretation
Pre-Test	20.198	.000	50.257	1.831	.073	3.231	-0.312	6.774	No Significant difference between groups before intervention
Post-Test	0.609	.438	-15.477	76	< .001	-34.000	-38.375	-29.625	Significant difference between groups after intervention

Pre-Test Analysis

Before the intervention, an independent samples t-test was conducted to determine whether both groups had similar levels of computational thinking skills. Levene's Test for Equality of Variances was significant, $F = 20.198$, $p < .001$, indicating that the assumption of homogeneity of variances was violated. Therefore, the "Equal variances not assumed" results were interpreted.

The analysis showed that there was no statistically significant difference between the treatment and control groups in the pre-test scores, $t(50.257) = 1.831$, $p = .073$. The mean difference between the groups was 3.231, with a 95% confidence interval ranging from -0.312 to 6.774.

Since the p-value was greater than .05, the null hypothesis failed to be rejected. This indicates that both groups had relatively similar computational thinking skills before the intervention was implemented. Therefore, the treatment and control groups were considered comparable at the beginning of the study.

Post-Test Analysis

After the intervention, another independent samples t-test was conducted to determine whether the CT Module influenced students' computational thinking skills. Levene's Test for Equality of Variances showed that the assumption of equal variances was met, $F = 0.609$, $p = .438$. Therefore, the "Equal variances assumed" results were used for interpretation.

The analysis revealed a statistically significant difference between the treatment and control groups in the post-test scores, $t(76) = -15.477$, $p < .001$. The mean difference between the groups was -34.000, with a 95% confidence interval ranging from -38.375 to -29.625.

As the obtained p-value was lower than the significance level of .05, the null hypothesis was rejected. The findings suggest that students in the treatment group achieved significantly higher computational thinking scores after participating in the CT Module compared to students in the control group.

Effect Size Analysis

An effect size analysis was conducted using Cohen's d to determine the magnitude of the difference in computational thinking skills between the treatment and control groups after the intervention.

The post-test results showed that students in the treatment group obtained substantially higher computational thinking scores ($M = 60.62$, $SD = 9.016$) compared to students in the control group ($M = 26.62$, $SD = 10.341$). Based on the pooled standard deviation, the calculated Cohen's d value was 3.50, indicating an exceptionally large effect size.

According to Cohen's (1988) guidelines, a value of 0.20 represents a small effect, 0.50 represents a medium effect, and 0.80 represents a large effect. Therefore, the obtained effect size far exceeds the threshold for a large effect, suggesting that the CT Module had a very strong impact on students' computational thinking skills.

The findings indicate that the improvement shown by the treatment group was not only statistically significant, but also educationally meaningful. Students who participated in learning using the CT Module demonstrated much stronger computational thinking skills compared to students who learned through conventional teaching methods.

The exceptionally large effect size may be influenced by the substantial difference in mean scores between the groups as well as the consistent improvement demonstrated by students in the treatment group. Overall, the findings provide strong evidence that the CT Module was highly effective in enhancing students' computational thinking skills

Effectiveness of Computational Thinking Module in Increasing Renewable Energy Awareness among Students

The analysis addresses the first research question which is:

To determine the effectiveness of computational thinking module in increasing renewable energy awareness among primary science students.

In conjunction with the research questions, researcher developed hypotheses:

H_1: There is significant difference in increase of renewable energy awareness between control and treatment group.

H_o: There is no significant difference in increase renewable energy awareness of between control and treatment group.

Descriptive Statistics

A descriptive analysis was conducted to examine students' renewable energy awareness scores in both the treatment and control groups before and after the intervention. The analysis focused on the mean scores and standard deviations to provide an overview of students' performance. Table 4 shows descriptive statistics for renewable energy scores.

Table 4: Descriptive Statistics for Renewable Energy Awareness Scores

Test	Teaching Method	N	Mean	SD
Pre-Test	Control	39	55.46	3.094
	Treatment	39	56.41	3.416
Post-Test	Control	39	62.33	3.702
	Treatment	39	88.97	8.219

The descriptive results show that both groups started with almost similar levels of renewable energy awareness before the intervention was carried out. The treatment group recorded a slightly higher mean score (M = 56.41, SD = 3.416) compared to the control group (M = 55.46, SD = 3.094). However, the difference between the two groups was small, suggesting that students had a comparable understanding of renewable energy concepts at the beginning of the study.

After the intervention, improvements were observed in both groups. However, the increase in scores was much more noticeable among students in the treatment group. Students who learned using the CT Module achieved a post-test mean score of 88.97 (SD = 8.219), while students in the control group obtained a mean score of 62.33 (SD = 3.702).

The findings suggest that the CT Module helped students improve their renewable energy awareness more effectively than the conventional teaching method. Although students in the control group also showed some improvement, the progress was considerably smaller compared to the treatment group.

In addition, the larger standard deviation in the treatment group's post-test scores indicates that students showed different levels of improvement after the intervention. Nevertheless, the overall increase in mean scores clearly demonstrates that the CT Module had a positive impact on students' understanding and awareness of renewable energy concepts.

Independent Sample T-Test Analysis

An independent samples t-test was conducted to examine whether there were differences in renewable energy awareness between students in the treatment group and those in the control group before and after the intervention. This analysis was appropriate because the study involved two separate groups of students, with

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

each participant belonging to only one group. Table 5 shows independent sample t-test result for renewable energy awareness scores.

Table 5: Independent Sample T-Test for Renewable Energy Awareness Pre-Post Test

Test Phase	Levene's Test F	Sig.	t	df	p	Mean Difference	95% CI Lower	95% CI Upper	Interpretation
Pre-Test	0.020	.887	-1.286	76	.203	-0.949	-2.419	0.521	No significant difference between groups before intervention
Post-Test	25.403	< .001	-18.457	52.806	< .001	-26.641	-29.536	-23.746	Significant difference between groups after intervention

Pre-Test Analysis

Before the intervention was implemented, an independent samples t-test was carried out to determine whether both groups had similar levels of renewable energy awareness. Levene's Test for Equality of Variances showed that the assumption of equal variances was met, $F = 0.020$, $p = .887$. Since the significance value was greater than .05, the results under "Equal variances assumed" were used for interpretation.

The analysis showed that there was no statistically significant difference between the treatment group and the control group in the pre-test scores, $t(76) = -1.286$, $p = .203$. The mean difference between the two groups was -0.949, with a 95% confidence interval ranging from -2.419 to 0.521.

As the p-value exceeded the significance level of .05, the null hypothesis failed to be rejected. This indicates that both groups started with relatively similar levels of renewable energy awareness before the intervention took place. Therefore, the groups were considered comparable at the beginning of the study.

Post-Test Analysis

After the intervention, another independent samples t-test was conducted to determine whether the CT Module had influenced students' renewable energy awareness. Levene's Test for Equality of Variances was significant, $F = 25.403$, $p < .001$, indicating that the assumption of equal variances was violated. Therefore, the results under "Equal variances not assumed" were interpreted.

The findings revealed a statistically significant difference between the treatment and control groups in the post-test scores, $t(52.806) = -18.457$, $p < .001$. The mean difference between the groups was -26.641, with a 95% confidence interval ranging from -29.536 to -23.746.

Since the obtained p-value was lower than .05, the null hypothesis was rejected. The results suggest that students who learned using the CT Module achieved significantly higher renewable energy awareness scores compared to students who were taught using conventional teaching methods.

Overall, the findings indicate that the CT Module was effective in improving students' renewable energy awareness. The large difference in scores between the two groups also suggests that the intervention contributed meaningfully to students' understanding and awareness of renewable energy concepts.

Effect Size Analysis

An effect size analysis was carried out using Cohen's d to determine the strength of the difference in renewable energy awareness between the treatment and control groups after the intervention.

The post-test results showed that students in the treatment group achieved much higher scores ($M = 88.97$, $SD = 8.219$) compared to students in the control group ($M = 62.33$, $SD = 3.702$). The calculated Cohen's d value was 4.16, which indicates an extremely large effect size.

Based on Cohen's (1988) guidelines, a value of 0.20 represents a small effect, 0.50 represents a medium effect, and 0.80 represents a large effect. Therefore, the obtained effect size in this study greatly exceeds the threshold for a large effect, showing that the CT Module had a very strong impact on students' renewable energy awareness.

This finding suggests that the improvement observed in the treatment group was not only statistically significant, but also meaningful in an educational context. Students who learned using the CT Module demonstrated a much better understanding and awareness of renewable energy concepts compared to those who experienced conventional teaching methods.

The large effect size may be explained by the considerable difference in mean scores between the two groups, as well as the consistent performance shown by students in the treatment group. This indicates that the intervention was effective for most students and was able to produce meaningful learning improvements across the group.

MANOVA Analysis

A Multivariate Analysis of Variance (MANOVA) was conducted to examine whether the CT Module and the conventional teaching method significantly affected students' computational thinking skills and renewable energy awareness simultaneously. The results of the MANOVA analysis are presented in Table 6.

Table 6: MANOVA Analysis Results

Effect	Multivariate Test	Value	F	Hypothesis df	Error df	Sig.	Partial η²
Intercept	Pillai's Trace	.924	454.899	2	75	< .001	.924
	Wilks' Lambda	.076	454.899	2	75	< .001	.924
	Hotelling's Trace	12.131	454.899	2	75	< .001	.924
	Roy's Largest Root	12.131	454.899	2	75	< .001	.924
Group	Pillai's Trace	.859	228.667	2	75	< .001	.859
	Wilks' Lambda	.141	228.667	2	75	< .001	.859
	Hotelling's Trace	6.098	228.667	2	75	< .001	.859
	Roy's Largest Root	6.098	228.667	2	75	< .001	.859

Note. Design: Intercept + Group.

The MANOVA results indicated a statistically significant multivariate effect of the teaching intervention on the combined dependent variables, namely computational thinking skills and renewable energy awareness. Pillai's Trace was selected for interpretation due to its robustness against violations of assumptions and inequal covariance matrices. The analysis showed a significant multivariate effect, Pillai's Trace = .859, $F(2, 75) = 228.67$, $p < .001$, partial $\eta^2 = .859$.

These findings suggest that the CT Module significantly improved students' computational thinking skills and renewable energy awareness when both outcomes were considered simultaneously.

Tests of Between-Subjects Effects

To identify which dependent variables contributed to the significant multivariate effect, univariate analyses were conducted. The results are presented in Table 7.

Table 7: Tests of Between-Subjects Effects

Dependent Variable	F	p	Partial η²
Computational Thinking	150.58	< .001	.665
Renewable Energy Awareness	280.31	< .001	.787

The univariate analyses revealed statistically significant differences between the treatment and control groups for both dependent variables. Students in the treatment group scored significantly higher in computational thinking skills, $F(1, 76) = 150.58$, $p < .001$, partial $\eta^2 = .665$. Similarly, significant differences were observed for renewable energy awareness, $F(1, 76) = 280.31$, $p < .001$, partial $\eta^2 = .787$.

According to Cohen's effect size interpretation guidelines, the obtained partial eta squared values indicate large effect sizes. These findings demonstrate that the CT Module had a substantial positive educational impact on both students' computational thinking skills and renewable energy awareness.

DISCUSSION

Research Objective 1 aimed to investigate the effectiveness of the Computational Thinking (CT) Module in improving students' computational thinking skills. The findings of this study demonstrated that the CT Module had a positive and significant effect on students' computational thinking abilities. The results showed that students in the treatment group achieved higher gain scores compared to the control group, indicating that the intervention successfully enhanced students' ability to apply computational thinking skills.

The demographic profile revealed that 72.14% of the students were from suburban areas in Keningau with relatively good digital access, while 27.86% were from rural areas with limited digital facilities. In this context, the combination of plugged and unplugged activities integrated in the CT Module proved suitable for students from different backgrounds and levels of digital accessibility. The findings support previous studies which emphasised that unplugged and plugged computational thinking activities complement each other effectively in enhancing students' computational thinking skills. For example, Sun et al. (2022) reported that introducing unplugged activities before plugged activities could significantly strengthen students' computational thinking skills while reducing the influence of prior programming experience. Similarly, studies by Hermans and Aivaloglou (2017), as well as Mark Guzdial (2022), highlighted that computational thinking extends beyond programming knowledge alone. Their findings suggested that unplugged learning activities improve participation, self-efficacy, and students' confidence in problem-solving tasks.

The positive impact of the CT Module can also be explained through Jean Piaget's Cognitive Constructivism Theory. According to the theory, meaningful learning occurs when students actively construct knowledge through experience, exploration, and social interaction. The CT Module incorporated hands-on and inquiry-based activities such as renewable energy investigations, simple experiments, surveys, discussions, and online quizzes. These activities encouraged students to participate actively in the learning process rather than passively receiving information. This aligns with the constructivist perspective that meaningful learning occurs through active engagement and reflection. Previous studies by Rands and Gansemer-Topf (2017) also suggested that constructivist learning environments encourage students to become co-constructors of knowledge while teachers function as facilitators. Therefore, the CT-module successfully supported collaborative learning, active participation, and deeper knowledge retention among students. Based on these findings and supporting literature, it can be concluded that the CT Module significantly improved students' computational thinking skills, and therefore Hypothesis 1 (H1) was supported.

Research Objective 2 focused on examining the effectiveness of the CT Module in increasing students' renewable energy awareness. The findings revealed that the CT Module positively influenced students' understanding and awareness of renewable energy concepts. Students who participated in the intervention demonstrated higher renewable energy awareness scores compared to students who received conventional instruction.

The demographic findings showed that most students came from families whose parents worked in logistics, farming, manufacturing, and small businesses, while a smaller proportion came from professional backgrounds such as teachers, doctors, and accountants. Despite differences in socioeconomic and educational backgrounds, the CT Module provided students with meaningful opportunities to learn about renewable energy through interactive and engaging activities. These included online quizzes, group discussions, student surveys, DIY experiments, and self-directed learning activities. Such learning experiences encouraged students to relate environmental issues to real-life situations and promoted greater environmental responsibility.

The findings are consistent with previous studies which reported that learning modules and experiential learning approaches positively influence students' environmental awareness and sustainability-related behaviour. For instance, Kumar et al. (2023) found that primary school students demonstrated strong climate change literacy when learning activities were aligned with their cognitive development level. Similarly, Lapawi and Husnin (2020) reported significant improvements in environmental science achievement among primary students using structured learning modules.

The improvement in renewable energy awareness can also be interpreted through the lens of Cognitive Constructivism Theory. Constructivist learning emphasises active participation, inquiry, reflection, and authentic learning experiences, all of which were integrated into the CT Module. Students were encouraged to explore environmental problems, discuss possible solutions, and apply their understanding through practical activities. Studies by Rohmawatiningsih et al. (2018) showed that constructivist-based environmental learning positively influences students' environmental care and critical thinking skills. Likewise, Ji and Wong (2025) highlighted that Problem-Based Learning within a constructivist framework enhances students' engagement and environmental understanding through authentic learning experiences.

In addition, Dziubaniuk and Nyholm (2021) emphasised that constructivist approaches are effective in sustainability education because they encourage critical thinking and meaningful participation. Similarly, Saldivar (2025) explained that reflective learning and self-construction of knowledge help students understand environmental issues more deeply. The CT Module extends these findings by integrating computational thinking with renewable energy education in a practical and engaging manner. Unlike previous studies that focused mainly on cognitive achievement, this study addressed broader aspects of awareness including knowledge, attitudes, and behavioural understanding. Therefore, the findings suggest that the CT Module provides a meaningful approach for promoting sustainability awareness among primary school students. Based on the findings and supporting literature, Hypothesis 2 (H2) was supported.

CONCLUSION

This study demonstrated that integrating computational thinking into renewable energy education through a structured CT-module significantly improved students' computational thinking skills and renewable energy awareness. The findings indicate that the module provided meaningful learning experiences that supported both 21st-century skill development and sustainability education among primary school students.

Implications for Theory and Practice

From a theoretical perspective, this study contributes to the growing body of knowledge on constructivist learning by providing empirical evidence that supports the integration of computational thinking, experiential learning, and problem-based learning within primary science education. The findings suggest that the development of computational thinking skills is influenced not only by technological tools, but also by effective pedagogical design and meaningful student engagement.

From a practical perspective, the findings provide evidence that CT-integrated science modules can be effectively implemented in primary classrooms to strengthen students' cognitive skills and environmental awareness simultaneously. The study also offers useful implications for curriculum developers, educators, and policymakers in promoting computational thinking and sustainability education within primary science curricula. Furthermore, the integration of plugged and unplugged activities makes the module suitable for schools with varying levels of technological access, particularly in suburban and rural settings.

Meanwhile, the study contributes to teachers by demonstrating a structured and contextually relevant instructional module which can elevate the integration of computational thinking and renewable energy education in primary science teaching. It offers pedagogical resource that may help teachers to create more engaging, interdisciplinary lessons aligned with 21-st century skills.

Limitations and Recommendations for Future Research

This study was conducted on a relatively small-scale involving students from a primary school in Sabah, which may limit the generalisability of the findings. Future studies should involve larger samples from different geographical and socioeconomic backgrounds, including rural, suburban, and urban schools, to examine the broader applicability of CT-integrated sustainability education.

In addition, the quasi-experimental design limits the ability to establish full causal relationships. Future research could employ longitudinal or multi-site studies to investigate the long-term effectiveness and scalability of computational thinking integration in science education. Researchers may also explore the individual effects of specific computational thinking components, such as decomposition, pattern recognition, abstraction, and algorithmic thinking, to determine which elements contribute most significantly to students' learning outcomes. Further studies could also investigate how different instructional approaches and scaffolding strategies influence students from diverse educational and technological backgrounds.

ACKNOWLEDGEMENT

Deepest appreciation to my supervisor for the continuous guidance, patience and encouragement. The support, constructive feedback and academic expertise have greatly contributed to successful completion of this study.

REFERENCES

1. Abas, A. (2016). Computational thinking skills to be introduced in school curriculum next year. News Straits Times. Retrieved from https://www.nst.com.my/news/2016/08/164732/ computational-thinking-skills-be-introduced-school-curriculum-next-year
2. Bakala, E., Gerosa, A., Hourcade, J. P., & Tejera, G. (2021). Preschool children, robots, and computational thinking: A systematic review. International Journal of Child-Computer Interaction, 29, 100337. https://doi.org/10.1016/j.ijcci.2021.100337
3. Bharathi, S., Murti, A., Binti, U., & Husin, M. (2022). The Effectiveness of Integrated Stem in Enhancing Energy Literacy Among Primary School Students in Malaysia. Al Qimah al Mudhafah the Journal of Management and Science (ALQIMAH), 6(1).
4. Cheng, L., Wang, X. & Ritzhaupt, A.D. A Meta-Analysis Examining the Effects of STEM + CT Interventions on Students' Computational Thinking in K-12 Education. J Sci Educ Technol (2026). https://doi.org/10.1007/s10956-025-10272-7
5. Dick, W., & Carey, L. (1996). The systematic design of instruction (4th ed.). HarperCollins.
6. Dziubaniuk, O., & Nyholm, M. (2021). Constructivist approach in teaching sustainability and business ethics: a case study. International Journal of Sustainability in Higher Education, 22(1), 177-197.
7. Easterbrook, S. (2014). From Computational Thinking to Systems Thinking: A conceptual toolkit for sustainability computing. Advances in Computer Science Research, 2. https://doi.org/10.2991/ict4s-14.2014.28
8. Fields, D. A., Shaw, M. S., & Kafai, Y. B. (2018). Personal learning journeys: Reflective portfolios as "objects-to-learn-with" in an e-textiles high school class. In V. Dagiene, & E. Jastu_e (Eds.), Constructionism 2018: Constructionism, computational thinking and educational innovation: Conference proceedings (pp. 213–223). Vilnius, Lithuania, http://www.constructionism2018.fsf.vu.lt/proceedings.
9. Gunckel, K. L., Covitt, B. A., Berkowitz, A. R., Caplan, B., & Moore, J. C. (2022). Computational thinking for using models of water flow in environmental systems: Intertwining three dimensions in a learning progression. Journal of Research in Science Teaching, 59(7), 1169-1203.
10. Guzdial, M. (2022). Providing students with computational literacy for learning about everything.
11. Hermans, F., & Aivaloglou, E. (2017). A controlled experiment comparing plugged first and unplugged first programming lessons. In Proceedings of the 12th Workshop on Primary and Secondary Computing Education (pp. 49–56). Association for Computing Machinery. https://doi.org/10.1145/3137065.3137068

12. Ismail, A., Hayati, M., Yatim, M., Sahabudin, N.A., Zuhaidah, N., & Zain, M. (2016). Keupayaan murid sekolah rendah mempelajari dan menerokai bahasa pengaturcaraan visual capability of primary school pupils in learning and exploring visual programing language. Journal of ICT in Education, 3, 89-97.
13. Jaya, S., Zaharudin, R., & Singh, P. S. S. A. (2025). Designing a computational thinking module for STEM teachers: a design and development approach. International Journal of Evaluation and Research in Education (IJERE), 14(3), 2197. https://doi.org/10.11591/ijere.v14i3.32540
14. Ji, W., & Wong, G. K. (2025, September). Integrating problem-based learning and computational thinking: cultivating creative thinking in primary education. In Frontiers in Education (Vol. 10, p. 1625105). Frontiers Media SA.
15. Khalid, M. B. M., Manap, W. B. A., & Hasan, N. (2025). Multi-Stakeholder feedback analysis of a Solar-Powered IoT Hydroponic STEM module: Impact, Perceptions and Optimization. Open MIND. https://doi.org/10.13140/rg.2.2.34381.70884
16. Kumar, A., Singh, A., & Gaurav, K. (2023). Assessing the synergic effect of land use and climate change on the upper Betwa River catchment in Central India under present, past, and future climate scenarios: A. Kumar et al. Environment, Development and Sustainability, 25(6), 5163-5184.
17. Lapawi, N., & Husnin, H. (2020). Investigating students' computational thinking skills on matter module. IJACSA) International Journal of Advanced Computer Science and Applications, 11(11), 310-314.
18. Lee, J., & Junoh, J. (2019). Implementing unplugged coding activities in early childhood classrooms. Early Childhood Education Journal, 47(6), 709–716. https://doi.org/10.1007/s10643-019-00967-z
19. Lee, I., Grover, S., Martin, F., Pillai, S., & Malyn-Smith, J. (2019). Computational Thinking from a Disciplinary Perspective: Integrating Computational Thinking in K-12 Science, Technology, Engineering, and Mathematics Education. Journal of Science Education and Technology, 29(1), 1–8. https://doi.org/10.1007/s10956-019-09803-w
20. Lodi, M., & Martini, S. (2021). Computational thinking, between Papert and wing. Science & Education, 30(4), 883–908. https://doi.org/10.1007/s11191-021-00202-5
21. Lye, S. Y., & Koh, J. H. L. (2014). Review on teaching and learning of computational thinking through programming: What is next for K-12? Computers in human behavior, 41, 51-61.
22. Lyon, J. A., & Magana, A. J. (2020). Computational thinking in higher education: A review of the literature. Computer Applications in Engineering Education, 28(5), 1174–1189. https://doi.org/10.1002/cae.22295
23. Mills, K., Coenraad, M., Ruiz, P., Burke, Q., & Weisgrau, J. (2021). Computational Thinking for an Inclusive World: A Resource for Educators to Learn and Lead. Digital Promise.
24. Ogegbo, A. A., & Ramnarain, U. (2022). Teachers' Perceptions of and Concerns About Integrating Computational Thinking into Science Teaching After a Professional Development Activity. African Journal of Research in Mathematics Science and Technology Education, 26(3), 181–191. https://doi.org/10.1080/18117295.2022.2133739
25. Osman, K., Halim, L., & Meerah, S. M. (2006). What Malaysian Science Teachers Need to Improve their Science Instruction. A Comparison across Gender, School Location and Area of Specialization. Eurasia Journal of Mathematics Science and Technology Education, 2(2). https://doi.org/10.12973/ejmste/75453
26. Rands, M. L., & Gansemer-Topf, A. M. (2017). The Room Itself Is Active: How Classroom Design Impacts Student Engagement. Journal of Learning Spaces, 6(1), 26-33.
27. Rijke, W. J., Bollen, L., Eysink, T. H., & Tolboom, J. L. (2018). Computational thinking in primary school: An examination of abstraction and decomposition in different age groups. Informatics in education, 17(1), 77-92.
28. Rohmawatiningsih, W., Rachman, I., & Kodama, Y. (2018). Improving critical thinking skills and environment caring attitude through integrated environment-based learning model. Journal of Sustainable Development Education and Research, 2(1), 69-73.
29. Saldivar, J. M. N. (2025). Crafting minds: A constructivist blueprint for Philippine education reform. Cognizance Journal of Multidisciplinary Studies, 5(1), 247-259.
30. Senin, S., Nasri, N. M., Senin, S., & Nasri, N. M. (2019). Teachers' concern towards applying computational thinking skills in teaching and learning. International Journal of Academic Research in Business and Social Sciences, 9(1), 296-310.

31. Su, Y. S., Wang, X., & Zhao, L. (2024). Constructing a computational thinking evaluation framework for pupils. IEEE Transactions on Education, 67(6), 878-888.
32. Shute VJ, Sun C, Asbell-Clarke J. Demystifying computational thinking. Educ Res Rev 2017; 22:142–58. https://doi.org/10.1016/j.edurev.2017.09.003
33. Suratnu, R. (2023). The adoption of the ADDIE model in designing an instructional module: The case of Malay language remove students. IJIET (International Journal of Indonesian Education and Teaching), 7(2), 262-270.
34. Tang, K. Y., Chou, T. L., & Tsai, C. C. (2020). A content analysis of computational thinking research: An international publication trends and research typology. The Asia-Pacific Education Researcher, 29(1), 9-19.
35. Yang, W., Gao, H., Jiang, Y., & Li, H. (2023). Beyond computing: Computational thinking is associated with sequencing ability and self-regulation among Chinese young children. Early Childhood Research Quarterly, 64, 324–330. https://doi.org/10.1016/j.ecresq.2023.04.006
36. Yang, W., Su, J., & Li, H. (2024). Demystifying early childhood computational thinking: An umbrella review to upgrade the field. Future in Educational Research, 2(4), 458-477.
37. Zeng, Y., Yang, W., & Bautista, A. (2023). Computational thinking in early childhood education: Reviewing the literature and redeveloping the three-dimensional framework. Educational Research Review, 39, 100520. https://doi.org/10.1016/j.edurev.2023.100520
38. Zeng, Y., Yang, W. Plugged versus unplugged: effects on kindergarten children's computational thinking and interest in programming. J. Comput. Educ. (2026). https://doi.org/10.1007/s40692-025-00384-9