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Evaluating the Effectiveness of a Project-Based Learning Module (*McodE)* in Solar Still Projects

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Abstract

This study evaluates the effectiveness of the *McodE* pedagogical module, a project-based learning approach, in enhancing computational thinking (CT) skills among STEM secondary school teachers through the integration of the Magnetcode application. Employing a case study design, 21 teachers participated in a virtual workshop that introduced the module, focusing on developing solar still projects as a platform for integrating STEM concepts and CT skills. The workshop emphasized ubiquitous learning environments and provided hands-on training with supplementary resources to support classroom application. Teachers applied the module in their classrooms, culminating in student project showcases that fostered creativity, problem-solving, and innovation. Data were collected through post-test questionnaires and observations of project showcases, and findings highlighted the module's success in integrating CT skills within STEM education. Teachers rated highly on the module's clarity, usability, and relevance to real-world issues like global warming and water scarcity. The Magnetcode application supported coding integration, though technical aspects received slightly lower ratings, indicating areas for improvement. Overall, the study concludes that the *McodE* pedagogical module effectively enhances CT skills while fostering engagement and creativity in STEM learning environments.

Keywords: Project-Based Learning, STEM Education, Computational Thinking, Magnetcode Application, Solar Still Projects

Introduction

The rapid evolution of technology and its integration into educational systems underscore the critical need to equip students with computational thinking (CT) skills, which are essential for problem-solving and innovation in the modern world (Nur Rahmawati et al., 2024). CT, a concept popularized by Wing (2006), encompasses a problem-solving process that emphasizes critical thinking, abstraction, and algorithmic reasoning. These skills are particularly vital in STEM (science, technology, engineering, and mathematics) education, which aims to prepare learners for the challenges of the 21st-century workforce.

CT has emerged as a cornerstone of STEM education, providing students with the tools to address complex problems and adapt to rapidly advancing technological landscapes (Nur

Rahmawati et al., 2024; Rabiee & Tjoa, 2017; Thissen, 2022) . Research highlights the importance of integrating CT into STEM subjects to foster interdisciplinary learning and cultivate essential 21st-century skills (Grover & Pea, 2017). Despite its importance, incorporating CT into STEM curricula presents significant challenges for educators, including the need for targeted pedagogical strategies and effective teaching tools (Kayan-Fadlelmula et al., 2022; Kerr et al., 2018).

To address these challenges, the *McodE* pedagogical module was developed as a project-based learning approach designed to enhance CT skills while fostering interdisciplinary connections within STEM education. For example, the module integrates a solar still project, enabling students to apply CT skills in a practical, cross-disciplinary context. However, many educators face barriers such as insufficient training and a lack of resources, underscoring the need for targeted interventions like project-based learning modules to support the effective integration of CT into teaching practices.

Project-based learning (PBL) is a student-centered approach that engages learners in real-world problem-solving activities, fostering deeper understanding and application of concepts (Chistyakov et al., 2023; Hsieh et al., 2022). Research has shown that PBL enhances student engagement, critical thinking, and collaboration while connecting theoretical knowledge to practical applications (Nurul Natrah & Ahmad Shidki, 2020; Prasetiyo et al., 2023) . When combined with CT, PBL can create dynamic learning environments that encourage creativity and innovation (Malik & Zhu, 2023). The *McodE* pedagogical module leverages the strengths of PBL to integrate CT into STEM education, using the solar still project as a meaningful and contextualized learning activity.

This study evaluates the effectiveness of the *McodE* pedagogical module, emphasizing its use of the Magnetcode application to integrate coding and CT elements into STEM education. The module's real-world focus on global challenges such as water scarcity and global warming provided a meaningful context for learning, encouraging creativity, collaboration, and innovation. This is aligned with sustainability in education SDG 4 and SDG 6 (UNESCO, 2016, 2018) This paper aims to assess the clarity, usability, and overall impact of the *McodE* module in supporting teachers' professional development and enhancing student learning outcomes in STEM education. The objective of this research is to evaluate the effectiveness of the *McodE* pedagogical module based on CT skills in topic heat for solar still. This research aims to evaluate the effectiveness of the *McodE* pedagogical module based on CT skills in topic heat for solar still projects.

Integration of the Magnetcode Application in McodE Pedagogical Module

The *McodE* pedagogical module is a project-based learning module designed to enhance computational thinking (CT) skills among secondary school STEM teachers. This module integrates the Magnetcode application, as a main microcontroller with various sensors to facilitate hands-on and real-world problem-solving. In the context of this research, the *McodE* pedagogical module is referred to as a Magnetcode application coding module implemented in the Solar Still project. It incorporates CT skill elements to seamlessly merge coding with STEM concepts.

The module employs a project-based approach, where teachers and students apply computational thinking to topic heat transfer, sustainability, and water purification. The Magnetcode application serves as the primary microcontroller for integrating coding into the Solar Still project, utilizing circuit simulations and virtual learning spaces to support CT skill development. The *McodE* module bridges STEM principles across physics, chemistry, and biology to enhancing understanding of heat in physics, water quality analysis in chemistry, and sustainable water use in biology. By fostering interdisciplinary learning and practical engagement, the *McodE* module equips STEM teachers with the tools to nurture computational thinking and innovative problem-solving in their classrooms.

Magnetcode application have introduce in the secondary schools in Malaysia, from year 2017, the Design and Technology subject gradually replaced the Integrated Living Skill subject (which was introduced since 1989) with the aim to integrated coding and programming in STEM subject (Ministry of Education, 2017; Rui et al., 2020). Magnetcode is free Android App for Coding and Circuit Simulation Controller. Magnetcode Application are available at Google Play. Teachers can download and allow the Magnetcode app to access the device by filling in “username” and “Password” to login. The Magnetcode application can be downloaded for free and used on an android or a tablet. Magnetcode Website can provide tutorials and guidance on starting projects, viewing others' projects, and posting the projects (Siang, 2020, 2022). Magnetcode uses simple Pseudocode in programming language. Pseudocode is an artificial and informal language that helps programmers develop algorithms (Anistyasari et al., 2018; Karatrantou & Panagiotakopoulos, 2008; Nita & Kartikawati, 2020).Pseudo code is a "text-based" detail (algorithmic) design tool. The rules of Pseudocode are reasonably straightforward. All statements showing "dependency" are to be indented. These include while, do, for, if, switch (Siang, 2020, 2022).

Pseudocode is a very useful device for specifying the logic of a computer program (or any important part of a computer program) before it is written, and for documenting the logic of a computer program after it has been written (Nita & Kartikawati, 2020). Literature explains a lot of definitions for the meaning of “pseudo-code”. It can be more general wording rather than the specific syntax and keywords of a programming language (Garner, 2006). According to Garner (2006) Pseudocode is:

> *A detailed yet readable description of what a computer program or algorithm must do, expressed in a formally styled natural language rather than in a programming language. Pseudocode is sometimes used as a detailed step in the process of developing a program. It allows designers or lead programmers to express the design in detail and provides programmers a detailed template for the next step of writing code in a specific programming language*

The following are examples of pseudocode used to stipulate the algorithm for converting a Celsius temperature to Fahrenheit (Garner, 2006)

Example 1
prompt user for a celsius temperature to be converted get input from user and store in a variable called celsiusTemp calculate: (celsiusTemp * (5/9)) + 32 and store in a variable called fahrenheitTemp display fahrenheitTemp

Example 2
BASE = 32
CONVERSION_FACTOR = 9/5 prompt user for celsius temperature input celsiusTemp fahrenheitTemp = (celsiusTemp * CONVERSION_FACTOR) + BASE output fahrenheitTemp

Incorporating CT Elements into the Solar Still Project
The *McodE* pedagogical module offers guidelines for developing the solar still project through the lens of computational thinking:

Abstraction the Key Concepts of the Solar Still Project
The sub-topic module emphasizing the importance of heat transfer, evaporation, and condensation as illustrated in Figure 1. The contents include an explanation of how heat transfer warms the water, leading to evaporation. This process separates the water from impurities, and the resulting vapor condenses on a cooler surface, allowing pure water to be collected. This guideline is essential for comprehending how the Solar Still functions and its practical applications in providing clean water.

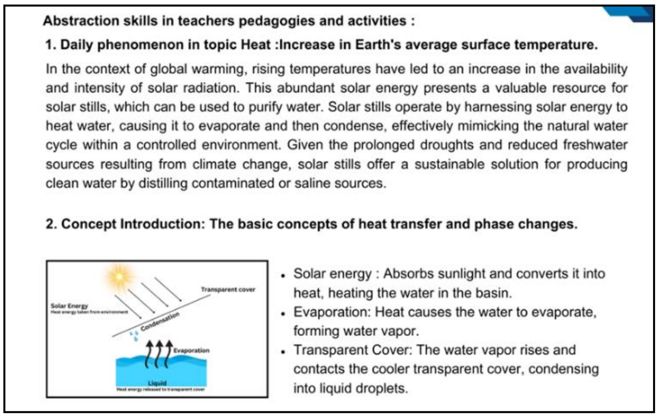


Figure 1 The Abstraction skills in teachers' pedagogies and activities

Through abstraction activities, the *McodE* pedagogical module guides teachers in presenting key concepts and discussing them with students. Visual aids, such as diagrams and videos of simple experiments, are provided to illustrate these concepts. STEM secondary school teachers can find additional resources on key concepts and visual aids by visiting the provided link.

Recognizing Patterns in Solar Still project using Sensor and Actuators
The second sub-topic focuses on recognizing patterns in Solar Still projects. This sub-topic emphasizes how to set up sensors and collect data from the Solar Still, including patterns in water levels, the timing of evaporation, and temperature changes. By analysing these patterns, teachers can encourage students to adjust optimize the Solar Still based on their findings. Figure 2 show the sensor and actuator set up particularly in the context of the solar still project.

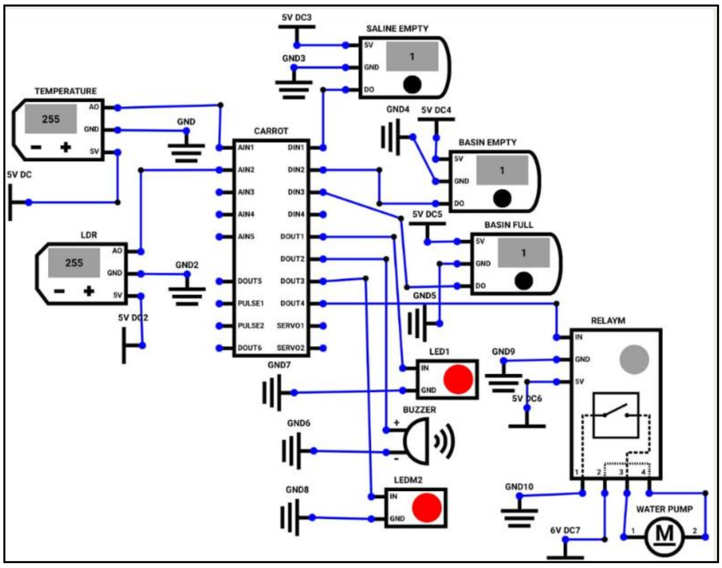


Figure 2 Pattern Recognition in Sensor and Actuator Setup

This sub-topic module covered the concept of sensor and actuator setup as show in schematic diagram in Figure 2. The *McodE* pedagogical module guide the teachers how to utilizes various sensor to monitor and optimize the solar still operation. The temperature sensor measures the temperature within the Solar Still, allowing teachers to identify patterns in how temperature affects the evaporation and condensation processes over time. The Light Dependent Resistor (LDR) detects light levels, which can be correlated with the effectiveness of solar energy in driving evaporation. By analysing patterns in light intensity, teachers and students can optimize the placement and timing of the Solar Still's operation. Additionally, water level sensors play a crucial role in monitoring the system: the "Saline Empty" sensor indicates when the saline water source is depleted, the "Basin Empty" sensor signals when the collection basin is empty, and the "Basin Full" sensor shows when the basin is full. Monitoring these sensors helps identify usage patterns and assess the efficiency of water collection, enabling teachers and students to make informed adjustments to enhance the Solar Still's performance.

Algorithm and Coding Commands

The sub-topic of the computational thinking skills covered the algorithmic thinking to enhance teachers' understanding and practical application of coding within the context of the Solar Still project. The sub-topic provide guided flowchart to outline the steps of coding commands for various sensors and actuators involved in the Solar Still project as illustrated in Figure 3.

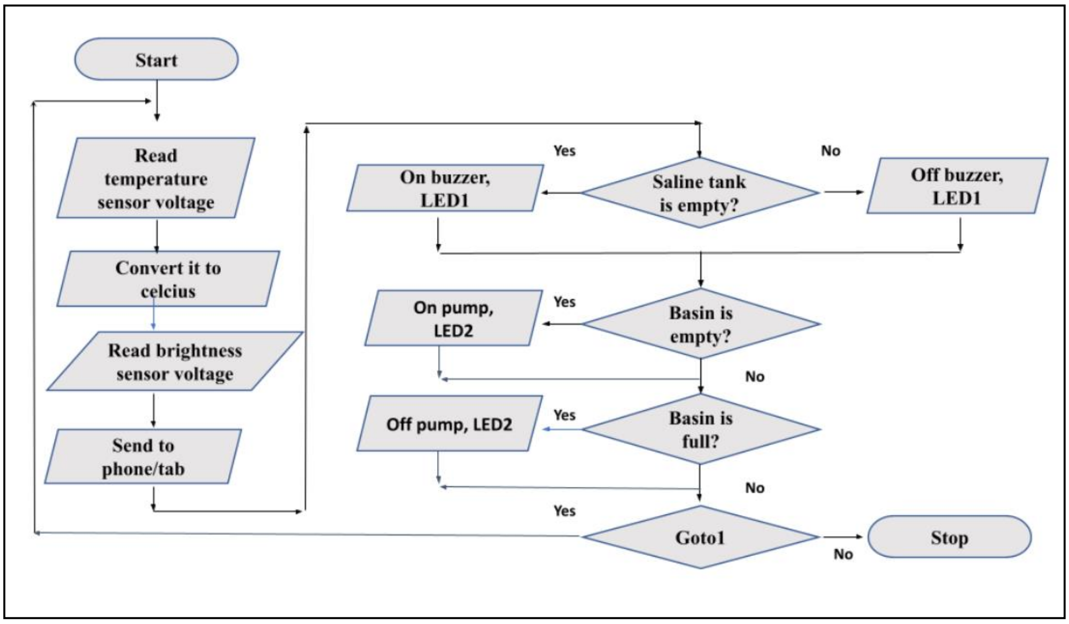


Figure 3 Flowcharts Outline for Solar Still Project

The *McodE* pedagogical module provides to STEM secondary school teachers how to guide students in creating flowcharts to outline the steps of coding commands for various sensors and actuators involved in the Solar Still project. The provided flowchart demonstrates a clear sequence of actions essential for understanding and implementing the project. The integration of the computational thinking skills through the process begins with reading sensor data, such as the temperature sensor voltage, which is converted to Celsius, and the brightness sensor voltage. The flowchart includes critical decision-making points, such as checking if the saline tank is empty, if the basin is empty, and if the basin is full. Based on these sensor readings and decisions, different actuators are controlled to ensure the efficient operation of the Solar Still. For instance, the buzzer (LED1) may be turned on or off, the pump (LED2) may be activated, and data may be sent to a connected phone or tablet. This structured approach helps teachers and students understand the logical flow of their program, making it easier to code and optimize the Solar Still.

The sub-topic also covered by the algorithm development to control the water pump and other components based on sensor input. The algorithm algorithmic thinking and coding approach is illustrated in Figure 4.

Figure 4 The Solar Still Coding Commands

Figure 4 illustrates how STEM secondary school teachers can develop algorithms using Magnetcode application involve reading sensor data, performing calculations and making decisions based on sensor input. The module contents provide the process to help teachers and students understand the use of commands for solar still system. The use of note in command *(~read and display Celsius, ~read and display LDR ADC, ~saline tank is empty, on led1 and buzzer)* guide teachers' understanding the purpose of each section of the code, making it easier to follow and debug.

Decomposing Solar Still Project into Components

The last sub-topic in computational thinking skills is decomposing solar still project into components to provided teachers' understanding in developing the project. The *McodE* pedagogical module provided the decomposition process involve breaking down the Solar Still project into smaller and more manageable tasks. Teachers can assign each student or group a specific component to concentrate on, such as design, coding, or construction as illustrated in Figure 5. This process allows students to focus on specific aspects of the project in detail as shown in Figure 6. This module cover on designing the physical structure of the Solar Still, ensuring it efficiently captures and condenses water vapor.

By dividing the project in this way, teachers can promote students' collaboration effectively, each contributing their expertise to complete the project successfully. The decomposition skills in *McodE* pedagogical module approach not only makes the project more manageable but also teaches students the importance of teamwork and the integration of various disciplines in solving complex problems.

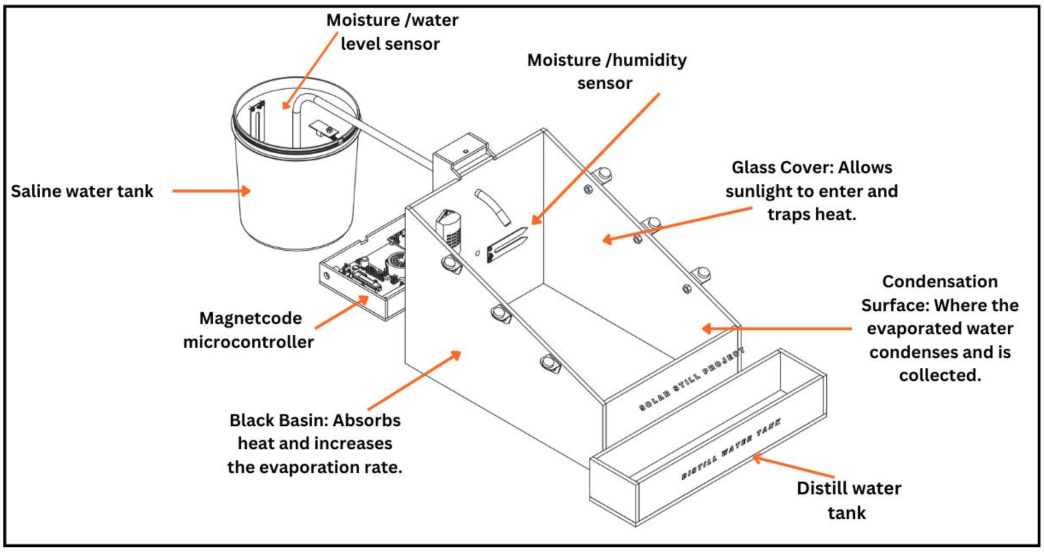


Figure 5 Designing the solar still project based on Physics, Chemistry and Biology Contents

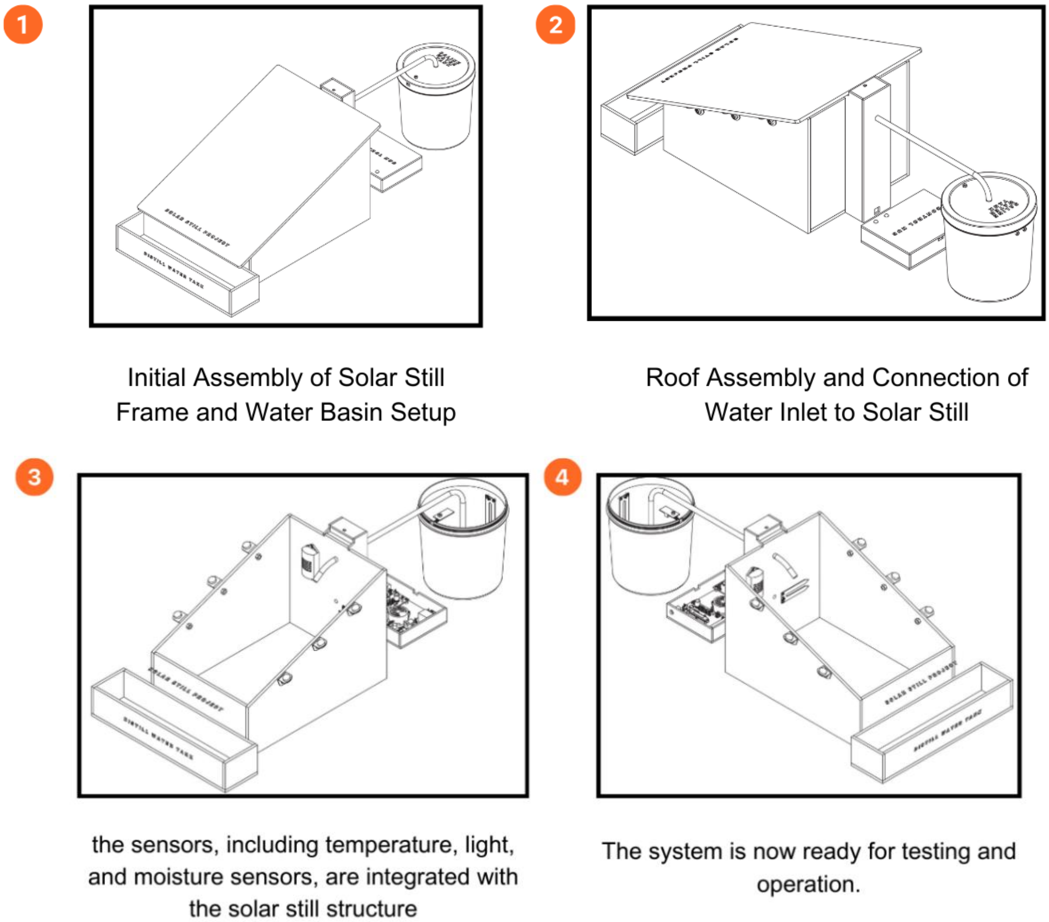


Figure 6 Decomposition Activity

Figure 6 illustrates the decomposition activity for the Solar Still project, where specific tasks are assigned to different groups of students. During the design phase, the *McodE* pedagogical module guides teachers in brainstorming and sketching the design of the Solar Still with their students. This phase includes planning the arrangement of necessary materials such as containers, tubes, sensors, and other supplies, as well as organizing how to gather these materials. The module also provides a step-by-step guide for constructing the Solar Still, ensuring that students can effectively collaborate and complete the project.

Methodology

This study employed a case study design to evaluate the effectiveness of the *McodE* pedagogical module in enhancing computational thinking (CT) skills among STEM secondary school teachers. The evaluation focused on teachers' experiences and assessments gathered through post-test questionnaires, along with observations of students' project showcases, to explore the module's usability, clarity, and its impact on teaching practices and student learning outcomes. Case studies typically involve small sample sizes and focus on achieving specific research objectives through a qualitative or quantitative approach (Schoch, 2020). In this study, 21 STEM secondary school teachers were selected using purposive sampling and participated in a post-test questionnaire following a learning workshop.

The study began with a virtual workshop conducted by the researcher, involving 21 STEM secondary school teachers, which served as the foundational phase for introducing the *McodE* pedagogical module. The workshop emphasized the integration of CT skills into STEM concepts, specifically through the development of a solar still project. Teachers engaged hands-on with the module and the Magnetcode application, a tool designed to seamlessly integrate coding and CT elements into STEM education. The workshop also emphasized ubiquitous learning spaces, highlighting that learning can occur in both online and physical environments (Bojer, 2019; Xiao et al., 2020). Teachers were supported with a detailed lesson plan and supplementary online resources to ensure effective implementation of the module in their classrooms.

Following the workshop, teachers transitioned into the classroom implementation phase, applying the *McodE* pedagogical module with their students. During this phase, students developed and presented their solar still projects, which provided a platform for real-world, problem-based learning that fostered creativity, innovation, and computational thinking (Barak, 2020; Chistyakov et al., 2023; Nurul Natrah & Ahmad Shidki, 2020). These projects culminated in a showcase where students presented their work, demonstrating their understanding of STEM concepts and CT skills. Teachers evaluated the module based on their classroom experiences and student outcomes. Data collection included a post-test questionnaire administered to the teachers, focusing on indicators such as the module's clarity, usability, and effectiveness in promoting CT and STEM skill integration especially in physics, chemistry and biology. Quantitative data from the questionnaires were analyzed to identify trends and summarize teachers' responses using descriptive statistics. Ethical considerations were maintained throughout the study, with teachers voluntarily participated and provided informed consent, and all data was anonymized to ensure confidentiality (Adley et al., 2024). This case study design provided a comprehensive evaluation of the *McodE* pedagogical module, generating insights into its effectiveness and practical recommendations for enhancing the integration of computational thinking into STEM education.

The questionnaire's validity was evaluated by three experts specializing in Psychometric Education, Curriculum, and Linguistics, ensuring both content and internal validity. The validation process emphasized the accuracy, format, and variables of the instrument to ensure alignment with the study's objectives. To assess reliability, the researcher conducted a pilot test with 30 teachers and calculated the Cronbach's alpha value, confirming the questionnaire's consistency (Cohen et al., 2018; Verma et al., 2024).

As the first step in the research protocol, the pilot study served as a smaller-scale version of the main study, assisting in planning and refining the research design(Arain et al., 2010; Janaka et al., 2024) The pilot test aimed to identify issues related to respondents' understanding and interpretation of the questionnaire items. It also assessed the time required to complete the questionnaire and gathered respondents' feedback to improve the instrument. Based on the findings from the pilot test, the researcher modified the survey questions accordingly.

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) Version 29.0 to assess the reliability of the items. Internal consistency was evaluated using Coefficient Alpha, as recommended by Ruekert and Churchill (2009), with items scored on a continuous scale ranging from "not effective" to "extremely effective." The summary of the total Cronbach's alpha value from the pilot test is presented in Table 1.

Table 1
Reliability Report for the Pilot Study

Cronbach's Alpha	**Cronbach's Alpa Based on Standardized Items**	**Items Mean**	**Variance**	**Std Deviation**	**N of Items**
0.83	**0.84**	**61.80**	**43.48**	**6.59**	**15**

Table 1.0 summarizes the reliability analysis for the 15 items, revealing strong internal consistency. The Cronbach's Alpha was 0.83 (0.84 for standardized items), indicating that the items consistently measured the intended construct. The overall scale had a mean of 61.80, a standard deviation of 6.59, and a variance of 43.48. These results demonstrate that the scale is reliable and can be confidently used to assess the construct with a high level of consistency across items.

Results and Discussion
The study was conducted through an online learning workshop among STEM secondary school teachers in Penang. The respondents' demographic data is summarized in Table 2.

Table 2
Respondents Demographics

Variables	**Percentage/N (%)**	
Gender	**Male**	**42.90% (N=9)**
	Female	**57.10% (N=12)**
Challenge Categories	**Biology**	**57.1% (N=12)**
	Chemistry	**14.3% (N=3)**
	Physics	**28.6% (N=6)**

Table 2 illustrated the respondents' demographics reveal that the majority were female, making up 57.1% (N=12) of the sample, while male respondents constituted 42.9% (N=9), indicating a higher participation rate among female teachers in the study. Additionally, respondents were categorized by their primary subject specialization, showing that Biology specialists formed the largest group at 57.1% (N=12), followed by Physics specialists at 28.6% (N=6), and Chemistry specialists at 14.3% (N=3).

Table 3
Post Test Findings

	N	Std. Deviation	Mean
1.The content of the solar still module effectively integrates concepts from biology, physics, and chemistry.	21	0.85	4.14
2. The content was relevant to real-world issues, such as global warming and water scarcity	21	0.56	4.29
3.The integration of subject content was relevant and helped deepen my understanding of STEM topics.	21	0.92	4.05
4.The solar still module' objectives helped me understand how coding can be integrated into STEM topics.	21	0.87	4.05
5.The solar still module' objectives supported the development of computational thinking skills.	21	0.66	4.33
6.The project-based approach was effective in promoting problem-solving skills into STEM subjects.	21	0.78	4.29
7.The hands-on activities helped me better understand the solar still project and Magnetcode application in STEM subject based content.	21	0.66	4.33
8. The activities promoted the integration of coding using the Magnetcode application.	21	0.77	4.24
9.The activities encouraged creativity and innovation	21	0.50	4.62
10.The Magnetcode application effectively supported the development of the Solar Still project.	21	0.94	3.90
11.The Magnetcode features were easy to use in implementing the project.	21	0.97	3.62

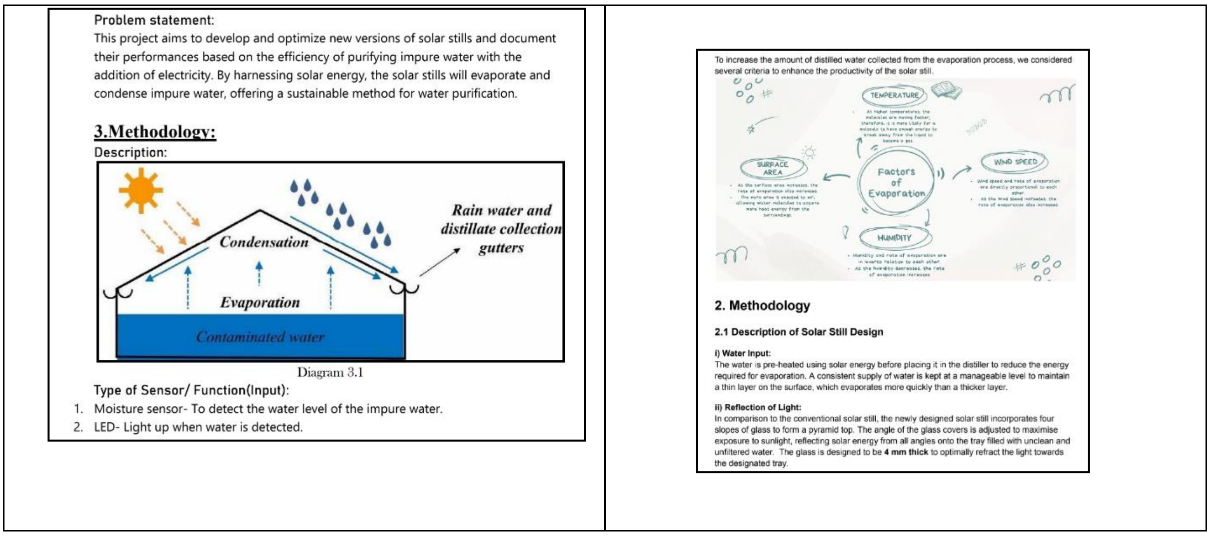
	N	Std. Deviation	Mean
12.The leaning space (virtual and physically) provided was conducive to carrying out the activities in the solar still module	21	0.83	4.10
13.The learning environment (virtual and physically) supported collaboration among participants.	21	0.92	4.05
14.The Solar Still module enhanced my understanding of computational thinking within STEM education.	21	0.73	4.14
15. I am satisfied with my overall experience of the Solar Still challenge.	21	0.74	4.38

Table 3 illustrates, the post-test analysis findings highlight the effectiveness of the *McodE* pedagogical module in achieving the research objectives, with high mean scores across key indicators reflecting its success in integrating computational thinking (CT) skills into STEM education. Teachers rated the integration of biology, physics, and chemistry content highly (mean = 4.14, SD = 0.85), indicating the module's success in bridging STEM disciplines. Its relevance to real-world issues such as global warming and water scarcity (mean = 4.29, SD = 0.56) further demonstrates its ability to contextualize STEM concepts meaningfully.

The module significantly enhanced understanding of STEM topics (mean = 4.05, SD = 0.92) and coding integration (mean = 4.05, SD = 0.87). Objectives related to developing CT skills received one of the highest ratings (mean = 4.33, SD = 0.66), showcasing the module's ability to foster 21st-century competencies. The project-based approach (mean = 4.29, SD = 0.78) and hands-on activities (mean = 4.33, SD = 0.66) were highly effective in promoting problem-solving, creativity, and innovation, with creativity-related activities receiving the highest rating (mean = 4.62, SD = 0.50).

While technical aspects like the Magnetcode application's effectiveness (mean = 3.90, SD = 0.94) and ease of use (mean = 3.62, SD = 0.97) showed room for improvement, the learning environment was positively rated for fostering collaboration (mean = 4.05, SD = 0.92) and engagement (mean = 4.10, SD = 0.83). Overall, the Solar Still challenge module enhanced computational thinking in STEM (mean = 4.14, SD = 0.73) and delivered high satisfaction with the learning experience (mean = 4.38, SD = 0.74).

To demonstrate the effectiveness of the *McodE* pedagogical module, the students' showcase in the Solar Still Challenge serves as a critical platform to evaluate the practical application and effectiveness of the *McodE* pedagogical module. The quality, creativity, and functionality of the solar still projects directly reflect how well students understood and implemented the workshop content facilitated by their teachers as show in Figure 7.



Problem statement:
This project aims to develop and optimize new versions of solar stills and document their performances based on the efficiency of purifying impure water with the addition of electricity. By harnessing solar energy, the solar stills will evaporate and condense impure water, offering a sustainable method for water purification.

3.Methodology:

Description:

Type of Sensor/ Function(Input):
1. Moisture sensor- To detect the water level of the impure water.
2. LED- Light up when water is detected.

To increase the amount of distilled water collected from the evaporation process, we considered several criteria to enhance the productivity of the solar still.

2. Methodology

2.1 Description of Solar Still Design

i) Water Input:
The water is pre-heated using solar energy before placing it in the distiller to reduce the energy required for evaporation. A consistent supply of water is kept at a manageable level to maintain a thin layer on the surface, which evaporates more quickly than a thicker layer.

ii) Reflection of Light:
In comparison to the conventional solar still, the newly designed solar still incorporates four slopes of glass to form a pyramid top. The angle of the glass covers is adjusted to maximise exposure to sunlight, reflecting solar energy from all angles onto the tray filled with unclean and unfiltered water. The glass is designed to be **4 mm thick** to optimally refract the light towards the designated tray.

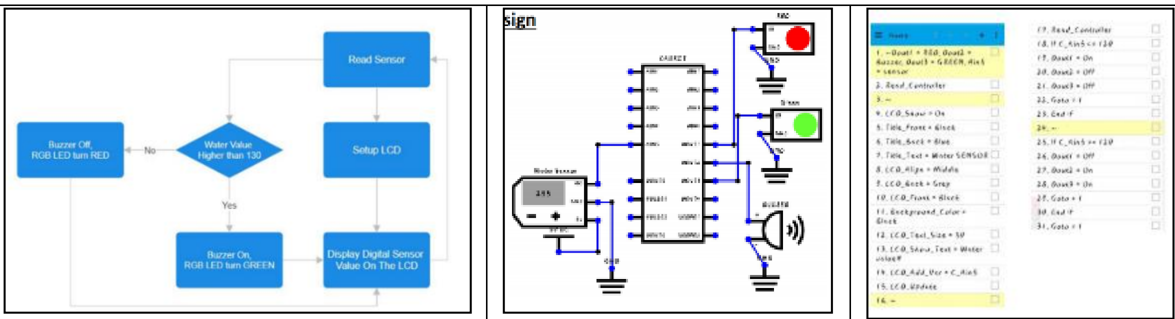
Figure 7 Students understand to incorporate the concepts of solar still project in Physics contents

The project reflected an understanding of fundamental scientific principles, such as condensation, evaporation, and solar energy, which were applied in a practical, real-world context, as shown in Figure 8.

Biology **Physics** **Chemistry**

Figure 8 The project ties together concepts from physics (light and heat absorption), biology (water purification relevance), and chemistry (phase changes like condensation).

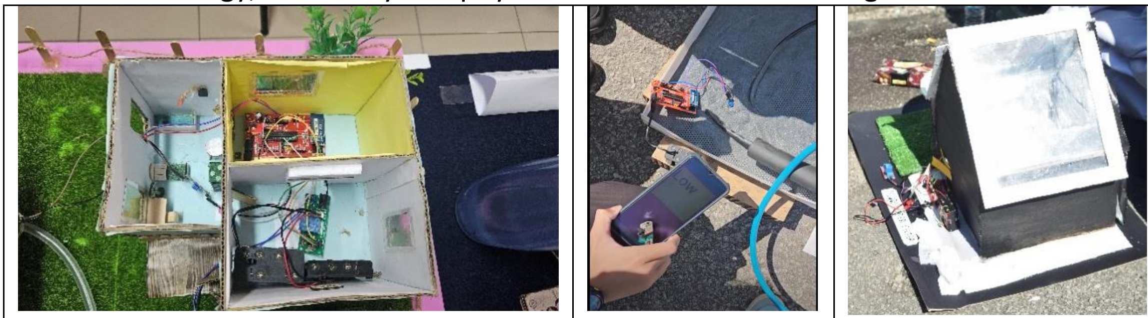
The *McodE* pedagogical module emphasizes the development of CT skills, such as decomposition, abstraction, algorithmic thinking and pattern recognition In this project, programming with Magnetcode enable students to create automated systems, such as water level monitoring and status feedback, reflecting CT principles into the solar still project as illustrates in Figure 9



Flow Chart **Circuit design** **Coding**

Figure 9 *The students understand how to incorporate the computational thinking skills into the solar still project.*

Each project effectively utilized the unique features of the Magnetcode microcontroller to address real-world challenges, demonstrating the *McodE* pedagogical module's success in fostering interdisciplinary STEM learning and computational thinking, was applied by the students in biology, Chemistry and physics contents as shown in Figure 10.



Biology **Chemistry** **Physics**

Figure 10 *The students understand how to incorporate the Magnetcode features into the solar still project*

The findings from the Solar Still project strongly aligned with the objectives of the *McodE* pedagogical module, which emphasize the integration of various STEM fields into a cohesive learning experience. The project demonstrated the application of physics through heat transfer and condensation principles in the solar still design, biology by addressing the importance of clean water for health and life, chemistry through the desalination and purification processes, and technology and engineering with the use of automation, sensors, and microcontroller programming via the Magnetcode application. This interdisciplinary approach was evident in the students' showcase, where they effectively combined theoretical knowledge with practical skills to address real-world challenges, such as water scarcity and global warming. The integration of creative problem-solving, hands-on activities, and computational thinking not only showcased the module's effectiveness in bridging STEM disciplines but also highlighted its success in fostering innovation, collaboration, and critical thinking skills among students, demonstrating the *McodE* module's potential to prepare learners for 21st-century challenges.

Conclusion

The *McodE* pedagogical module has proven to be an effective approach for enhancing STEM learning, particularly in the fields of physics, chemistry, and biology. By integrating these disciplines within real-world contexts, such as the Solar Still project, the module successfully bridges theoretical concepts with practical applications, fostering a deeper understanding of scientific principles. The inclusion of the Magnetcode application further amplifies this impact by emphasizing the importance of computational thinking, both for teachers and students. Teachers were able to deepen their understanding of Magnetcode coding, enabling them to integrate computational thinking seamlessly into STEM content delivery, while students utilized these tools to enhance their projects. The project-based learning approach adopted in the *McodE* module has been highly effective in nurturing both teachers and students in STEM education. For students, it fostered creativity, problem-solving, and collaboration, while providing hands-on experience that connects classroom learning with real-world challenges. For teachers, the approach strengthened their pedagogical skills and equipped them with practical strategies to incorporate computational thinking into their teaching practices. Together, these outcomes highlight the *McodE* pedagogical module's capacity to prepare educators and learners to meet the demands of 21st-century STEM education, making it a powerful tool for advancing interdisciplinary learning and equipping future generations with the skills needed to address global challenges.

This research contributes to the integration of computational thinking (CT) skills into STEM education through the *McodE* pedagogical module, which employs project-based learning (PBL) and the Magnetcode application to bridge theoretical knowledge with real-world applications. It provides a replicable model for embedding CT skill, such as abstraction, pattern recognition, and algorithmic thinking into interdisciplinary STEM projects. The *McodE* pedagogical module demonstrated through a Solar Still project addressing global challenges like water scarcity and climate change. The study enriches existing knowledge by aligning STEM education with sustainability goals, offering an accessible framework for educators to incorporate coding into their teaching practices effectively. Its contextual significance lies in addressing practical barriers to CT integration in resource-constrained settings, particularly within the Malaysian education system, while offering a model with global applicability for fostering interdisciplinary, innovative, and sustainability-focused learning (Bunyamin & Finley, 2016; Siti Hamizah Aspin et al., 2022).

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