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Creative Teaching STEM Module: High School Students' Perception

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Abstract: This study aimed to investigate the impacts of enrolling in the creative teaching module in science, technology, engineering, and mathematics (STEM) education from high school students' perspectives. This study applied a case study and qualitative research approach involving 26 Grade 11 students and 31 Grade 8 students. The creative teaching-STEM (CT-STEM) module, which comprised various activities related to energy literacy in real-world situations for the community's well-being, involved outdoor STEM education activities with the assistance of two science teachers. The CT-STEM module was developed based on the directed creative process model by applying four creative teaching strategies: (i) constructivism learning, (ii) discovery inquiry, (iii) problem-based learning, and (iv) project-based learning. The theme of these out-of-classroom activities is sustainability education, focusing on energy sustainability. The results showed that the planned approaches could positively impact and build students' creativity and create an exciting learning experience. Furthermore, the findings from the open-ended questionnaire instrument, observations, and analysis of the worksheets have shown enhancements in five themes: the development of problem-solving skills with an emphasis on the element of sustainability education, high-level thinking skills, active learning skills, communication skills, and humanity skills. The students also showed an increased interest in STEM as they learned using the CT-STEM module.

Keywords: *Creative teaching modules STEM, creativity, energy sustainability, STEM education, student's perception.*

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Introduction

The acronym 'STEM' stands for science (S), technology (T), engineering (E), and mathematics (M). The literature has presented different definitions or perspectives on STEM education. Initially, STEM education aimed to integrate four components, science, technology, engineering, and mathematics (Öztürk, 2021), but at present, STEM education refers to the integration of technology and engineering design concepts into the field of science and mathematics education. Consequently, many parties have highlighted STEM education's potential to meet all requirements to improve the quality of general education (Hanif et al., 2019). STEM education highlights the students' ability to solve real-world problems (Loh et al., 2019). Students' engagement in real-world problem solving is facilitated through student-centred pedagogies and the integration of different STEM disciplines, in line with developing 21st-century skills among students.

STEM education plays an important role in helping students develop different skills. It provides multidisciplinary opportunities that allow creative knowledge integration and fosters development in each STEM area (Marcelo et al., 2021). It is important to note that in organising STEM programs, school education initiatives should improve students' overall performance in mathematics and science and increase students' opportunities for STEM-related careers (Swagerty & Hodge, 2019).

Since STEM education holds importance for the future of a country (Oh et al., 2013; Tuner, 2013), Malaysia emphasises STEM education to become a developed country that can meet the challenges and demands of an economy driven by STEM. However, until today, the Malaysian education system's goal of a 60:40 ratio policy of science and literature, introduced in the Malaysian education system in the 1970s (Ministry of Education Malaysia, 2013), has yet to be achieved, with a worrying trend of decline. Malaysia's performance in Trends in International Mathematics and Science Study (TIMSS) has been inconsistent since its first involvement in 1999 (Muhammad Hafizi & Kamarudin, 2020). Malaysia's

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performance is still far behind compared to other Asian countries, such as Singapore and China. Table 1 shows the achievement position of Malaysian students in TIMSS in 2015 and 2019.

Table 1. Malaysia's Achievements for Mathematics and Science in TIMSS for 2015 and 2019 (Ministry of Education Malaysia, 2016a, 2020)

	Year	Malaysia	Singapore	Chinese Taipei	Malaysia's Position According to Mathematics Content Domain
Mathematics Score	2015	465	621	599	22/39
	2019	461	616	612	28/39
Science Score	2015	471	597	569	24/39
	2019	460	608	574	29/39

Malaysia's position in TIMSS reflects that an average Malaysian student fails to acquire the minimum skills for mathematics and science, and the percentage of Malaysian students who are highly competent in the two subjects is low (Ministry of Education Malaysia, 2020). Based on the TIMSS 2019 national report on the level of student's competency in science subjects, only 8% of Grade 8 students in Malaysia were highly competent in science, 47% showed average competency, and 45% showed limited or no competency. Therefore, the Government of Malaysia has taken several initiatives to address this problem, including implementing a creative approach to STEM teaching and learning. Consequently, this research aimed to identify the impacts of Creative Teaching-STEM modules (CT-STEM modules) on Grade 8 and Grade 11 students through learning activities outside the classroom.

Literature Review

Creativity in STEM Education

The first step to increasing creativity among students is to support the development of individuals with knowledge and ability in various skills (Mathiphatikul et al., 2019). Creativity is important in human capital development as it helps individuals cope, adapt, and succeed in a rapidly changing world by thinking creatively. Moreover, creativity is an important asset in human life, especially in the era of globalisation (Mróz & Ocetkiewicz, 2021; Muhammad Hafizi & Kamarudin, 2020). On the other hand, it is a hidden talent among many people because creative individuals are sensitive to the world around them. They think independently and creatively, solve problems efficiently, and possess analytical and critical minds. Studies have also reported that creative individuals believe in themselves; they are open to new experiences, highly disciplined and not afraid to take risks. Today, creativity is a determinant of success in achieving goals and completing tasks and is one of the conditions that must be present in developing one's potential. This is because the world requires not only political scientists and technologists but also ordinary citizens to collaborate and solve problems creatively and solve global challenges quickly and realistically (Azevedo et al., 2017). Quick reflection from different individuals can decrease the inherent risks, uncertainties and errors that can affect the action taken.

Although all manufacturing and construction of solutions require creative thinking, and creativity is required for inventive thinking in almost every domain, it is not appreciated in many formal educational environments. Therefore, it is essential to encourage creativity in school. In this regard, applying creativity can help students think about information and implement it to overcome real-life problems in novel and useful ways (Huang & Wang, 2019). Creativity can be formed in classrooms to make students more interested and involved in the learning experience. Creative teaching and learning can divert the students' attention to exploring something new based on problem-solving.

Studies have reported a close relationship between creative teaching and learning approaches in STEM education. Weng et al. (2022) concluded that CT-STEM strategies fostered students' creativity, competency and motivation to explore more problem-solving. This finding was in line with Sirajudin et al. (2021), who also argued that STEM education effectively influenced students' creative thinking ability compared to traditional studies. Creativity developed through STEM education causes students to understand the content better and increases their ability and motivation to solve problems (Conradty et al., 2020; Purwadi, 2021). In turn, it can increase confidence and teamwork (Maegala et al., 2021; Weng et al., 2022) and enable students to integrate their knowledge with the engineering design process (Sasangbong & Huntula, 2022).

Teachers must plan strategies to support students' creativity and innovation. According to Hobri et al. (2019), teachers can provide realistic open-ended problems during teaching and learning to explore students' creative thinking processes by gauging the student's ability to develop the answers and ways to solve the problem. A study by Mróz and Ocetkiewicz (2021) focused on the development of creativity in Polish adolescents and found that teacher seniority, school location, and choice of teaching methods influenced the development of students' creativity. Implementing STEM education in schools requires frequent assignment assessments based on creativity development.

Creativity is an integral part of 21st-century skills and is emphasised in the science education co-curriculum (Altan & Tan, 2021). Gaining knowledge is no longer the main purpose of education, and traditional problem-solving methods are less relevant to solving various new problems effectively. Instead, the ability to creatively use knowledge and create new knowledge (Mróz & Ocetkiewicz, 2021) is an important addition to the present purpose of education to enable the community to solve any problem. Creative thinking can spur new and original ideas to solve problems and explore opportunities (Mathiphatikul et al., 2019). Thus, creative thinking should be practised through the STEM education system (Purwaningsih et al., 2021) so that students can come up with innovative creations in the future.

Even though STEM education has the main requirements to ensure that a country can compete globally to increase progress, it always experiences different innovations throughout its development (Hobri et al., 2019; Sirakaya et al., 2020). Furthermore, teachers teaching mathematics, science, and technology cannot integrate learning content and STEM activities (Thingwiangthong et al., 2021). Two important features in STEM education are integration and real-world problem solving (Loh et al., 2019). Hence, STEM education must combine education and discipline to help students understand ideas and concepts. In other words, integrating science, technology, engineering, and mathematics is the core of STEM (Diana et al., 2021; Utamni et al., 2021). Consequently, this STEM integration develops individuals who can think creatively, invent, and solve complex problems. STEM education can increase the interactions that form certain student experiences by creating lessons based on experience.

The Need to Develop Creativity as a Key Component of Sustainability in STEM Education

The complexity of modern life and the challenges for sustainable and inclusive development require new skills to efficiently address contemporary problems (Bezerra et al., 2021). Creativity is one of the key skills needed to drive the development of a country, especially in an increasingly complex social environment, to ensure that progress does not threaten global sustainability. Without competency in creativity, sustainable development may not be feasible. Creativity allows a person, for example, to find methods of sustainable management of natural resources, alternative conflict resolutions, and new and effective business solutions using new technologies and other methods. Therefore, students must learn to associate creativity with sustainability (Mróz & Ocetkiewicz, 2021).

Successful implementation of sustainable development through education requires deliberations through regional and global initiatives to address the global sustainability challenges in a fundamental and timely manner (Hobusch & Froehlich, 2021). Special attention must be paid to students to produce a new generation sensitive to the diverse global sustainability issues. One of the most important global sustainability issues is generating and applying energy without polluting the environment (Ministry of Education Malaysia, 2016b). Thus, to ensure effective education on environmental and sustainable development (ESD), the content must be implemented through various educational activities and integrated with the school systems through formal education in the classroom or through non-formal education activities outside the classroom. Education for sustainable development allows students to understand changes in the real world, predict the future, identify problems present in both current and future societies, and make decisions collaboratively (Suh & Han, 2019).

Energy sustainability has been a concern for a long time because energy resources are critical for a country to achieve economic, social, and political prosperity. The current generation needs to be given an early education and awareness of the importance of wisely managing energy resources so that energy resources do not deplete. For sustainable development education, a recent study has indicated creativity as a key skill in thinking and problem-solving skills in learning sustainability (Carlos et al., 2019). Besides that, Chen and Chen (2021) focused on nurturing students' creativity through STEM inquiry methods. They discovered that the inquiry activities provided self-directed learning opportunities to help students apply what they have learned in real life. Therefore, creativity should be instilled among students, for instance, creativity in energy generation and energy resources management.

Directed Creative Process Model

STEM education is needed to fulfil the high demand for STEM-based careers. Qualified STEM graduates are future leaders, scientists, engineers, and others. Hence, they should be able to compete globally and solve challenging problems creatively (Barry et al., 2018). However, STEM education programmes still lack the development of creativity, hindering the achievement of STEM goals. There is a need for an appropriate STEM education environment to encourage creative thinking and develop creativity in students. In short, STEM education needs a suitable learning model to achieve its objectives (Diana et al., 2021).

Many teachers may not be familiar with integrated STEM approach to teaching and learning (Loh et al., 2019). Therefore, suitable guidelines and resources must be provided to assist educators in integrating STEM into teaching and learning. The development of the CT-STEM module is an effort to implement STEM education successfully. In the CT-STEM module, various creative teaching strategies are included as a guide to creating a creative learning environment for the students. An 'energy sustainability' themed CT-STEM module was created based on the directed creative process model, and it applied four creative teaching designs: (i) constructivism learning, (ii) discovery inquiry, (iii) problem-based learning, and (iv) project-based learning. Figure 1 illustrates the creative teaching plan using the four phases in the directed creative process model.

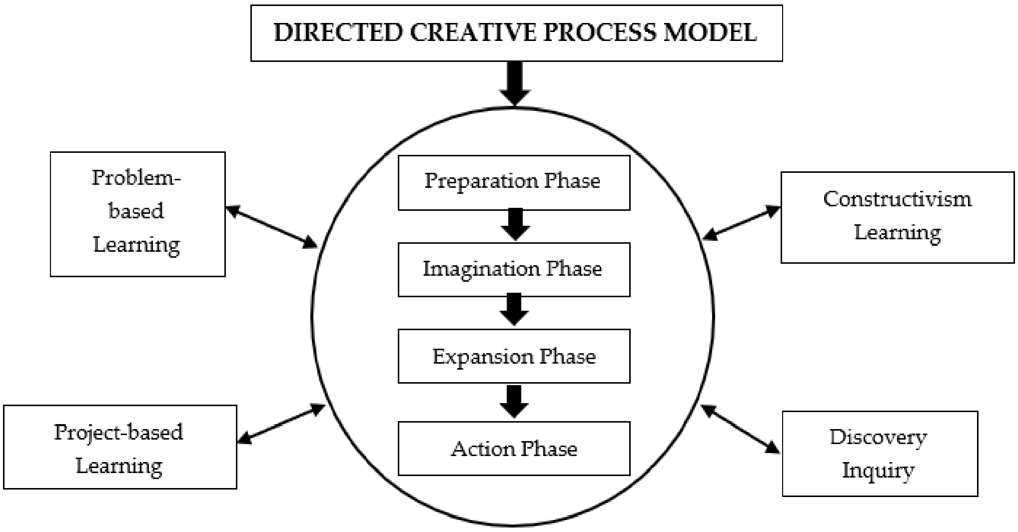

Figure 1. Creative Teaching Plan by Using Four Phases in the Directed Creative Process Model (Ministry of Education Malaysia, 2011)

Applying various teaching strategies will create different experiences for students to prevent boredom and increase anticipation for the next activities. There are four main phases in the directed creative process model (Ministry of Education Malaysia, 2011): (i) preparation phase, (ii) imagination phase, (iii) expansion phase, and (iv) action phase. The model presents a comprehensive guideline for creating new creative teaching modules centred on the students because it has the following characteristics: (i) combines various concepts of creative thinking models that include creative problem-solving model and creative decision-making; (ii) balances imagination and analysis; (iii) includes critical and creative thinking; and (iv) involves both mental processes-cognition and metacognition.

Creative lesson planning begins with the observation of daily life phenomena. The lessons focus on the global sustainability issues under the theme of 'energy sustainability' before stating the problems. The students are challenged to explain and produce a product through collaborative group work. This method is intended to encourage students to think critically and creatively and develop their problem-solving skills related to energy sustainability. Activities in the CT-STEM module, according to the theory of cognitivism, are the process of learning or knowledge acquisition that is organised through information processing, and then it is stored and interpreted as useful information. Furthermore, a specific feature of constructivism, student-centred learning (Diana et al., 2021), is applied during the activity implementations to develop students' independent skills and study by themselves. Constructivism theory centres on the students while teachers facilitate to help students solve problems by themselves.

Creative thinking involves observing, deciding, and solving a problem correctly and innovatively through teaching and learning. Thinking creatively is required to make decisions and accurately innovate while solving problems (Kartikawati & Nita, 2019).

Methodology

Research Design

This research combined case and qualitative studies to discover the students' perceptions of the CT-STEM module based on their experiences. The activities in the module were conducted in groups by high school students and were assisted by two teachers. In the CT-STEM module, six activities were conducted based on the theme of 'energy sustainability': (i) Newton Laws, (ii) Electric base and Ohm Law, (iii) Faraday Law, (iv) Global Environment, (v) Sustainability in Power Generation, and (vi) Renewable Energy.

Research Participants

The participants were selected through the purposive sampling method. The study was conducted on 31 Form 2 (Grade 8) students and 26 Form 5 (Grade 11) students from the same school. Students from two different grades were selected to identify the suitability of the CT-STEM module. The selected students have never been involved with STEM education programs outside the classroom. The study was implemented outside the classroom and had a suitable arrangement for group work.

Research Instrument

The research instruments used were worksheets, classroom observation forms, and open-ended questionnaires. The details for each instrument are as follows:

- The students' worksheets were used to investigate the development of creative thinking and students' progress after going through an activity under the STEM educational program. Every group was provided with only one set of worksheets for each activity.
- The classroom observation forms were used to observe the students' behaviour while doing the activities.
- The open-ended questionnaires were used to gather individual students' opinions on the CT-STEM module.

Data Collection and Analysis

Each group was instructed to complete a group worksheet in every study session. The items in the worksheets were based on module activities that focused on creative thinking skills, and the worksheets were handed out after each activity. Exercises in the module were planned to strengthen the student's understanding. The students were given opportunities to build and present a new model as a group. The finished works were submitted to the teacher once it was done. These works were graded during discussion sessions between the teachers and researchers.

The researchers used a set of classroom observation forms to collect the classroom observations during the lessons. However, it was sometimes difficult to collect observation data in the field. Hence, the researcher also made recordings during the lessons. After each lesson, the researcher reviewed the notes on the observation form based on the observation recordings. Recording students' activities are important to verify classroom observation data.

The students were also given some time to answer the open-ended questionnaire (student reflection form) at the end of each activity. The students were instructed to do self-reflection in the reflection form as an assessment. Their feedback allowed the researchers to monitor and modify the instructional design to improve the module quality. The students' study progress was also rated progressively based on these reflection and observation data to help determine the suitability of using the CT-STEM module in STEM education.

The data was qualitatively and thematically analysed. The themes were derived from the findings of the open-ended questionnaires, observations, and student worksheet answers. The data analyses were conducted by arranging the data in a table and diagram to get an overview of the information obtained. Discussions with experts in the qualitative field were also conducted to ensure the appropriateness of the formed themes.

A code system was used to represent each respondent and their data. For the open-ended questionnaires, to record the respondents, the researchers used *S* as students, *G8* for Grade 8 students and *G11* for Grade 11 students, followed by a number system. For example, *SG815* refers to the 15th Grade 8 student. The collected data source types were coded as *WS* for worksheets and *OB* for observation. The worksheets were labelled with numbers to determine their position in the module and the observations made. The numbers were also used to indicate the student grades, groups, and activity numbers/sequences. For example, *OB84* represents the observations of the fourth activity involving Grade 8 students, while *WS8K34* represents the worksheets from the fourth activity involving the third group of Grade 8 students.

The data analysis results provided information on the effectiveness of using the CT-STEM Module. This study's observations focused on the impact of creative teaching. The value of creativity was observed through the students' groupwork answers from the worksheets and the student's answers in the open-ended questionnaires. The students' creativity was also assessed based on their responses while performing activities and through the products, they produced to solve a problem.

Findings

Apart from enhancing creativity, the CT-STEM module could give students a fun learning experience and generate interest and curiosity to encourage students to keep learning. An active and fun learning environment improves students' problem-solving, high-level thinking, active learning, communication, and humanity skills. The findings are explained thematically as follows:

Problem-Solving Skills Related to Sustainability Education

The knowledge gained from STEM and sustainability education improved the students' skills in problem-solving. Students could link STEM education with sustainability education when it was taught in a relevant way and adapted to life experiences related to them. In addition, the ability to think creatively and critically would allow students to build new knowledge for themselves and their group members based on the student's responses that STEM education was broad, interesting, and important in preserving environmental sustainability. Using the CT-STEM module allowed them to learn in-depth about the importance of sustainability education.

The following students' reflections support the above statement:

"These methods make it easier for students to understand science concepts and the ability to apply them. Applying what we have learned makes students more creative and innovative" *(SG1120)*.

"These types of programs should be done regularly because they can increase students' quality in a lot of aspects, such as creativity, open-mindedness, accepting the views of others and pursuing innovation" *(SG1126)*.

However, creative learning requires adequate time allocation to implement STEM activities successfully. By allocating sufficient time, the students' creative effort while creating a prototype would not be stopped halfway, avoiding disappointments. This situation could be detected from *SG812*'s reflection while completing their mini hydroelectric task:

"At first, I was excited, but now I'm a little disappointed because I didn't get the chance to complete the task because the time given was too short" *(SG812).*

Meanwhile, from the observation, the researchers saw that the students were unhappy when the teacher stated that the given period had expired (*OB87*).

High-Level Thinking Skills

The learning approaches in the CT-STEM module included constructivism, discovery inquiry, problem-based learning, and project-based learning, all of which required the students to develop their knowledge. Indirectly, these approaches could stimulate their mind to think from different perspectives to complete the given task. For example, a student suggested using carbon mechanical pencils to replace carbon rods as electrodes (*WS8K18*).

Moreover, the students in groups could have various and different opinions; hence, they were required to analyse each opinion to decide on the right decision and create the best quality group work. Elements of creativity and innovation could also be produced in the presence of various opinions. This matter was agreed upon by most of the students. *SG1118* opined that they needed to assess the best opinion among their group. The best opinion should refer to the creative and innovative opinion. According to *SG1118,*

"A lot of group members gave their opinions. Therefore, we tried to think and choose the best opinion every time we did an activity. We prioritised creative and new opinions" *(SG1118)*.

The 'fruits and vegetable' activity was about the concept of how fruits and vegetables generated electric current, as evident by the lit LED. This activity encouraged the students' high-level thinking skills, creating various creative and innovative ideas. *SG1122* opined,

"Learning using the CT-STEM module stimulates the students to think critically on every question the teacher gives. We must think more creatively so that I can relate them to nature and my daily life" *(SG1122)*.

Active Learning Skills

Creative teaching approaches were applied to create an active and interesting learning environment. All students stated that the CT-STEM education gave them a fun learning experience, leading them to participate in group work. A creative teaching plan exposed the students to an active and creative learning environment. Creativity in teaching and learning could be linked to materials development and approaches that encourage the student's interests and motivation. Most students opined that learning following the CT-STEM module required them to be reactive and to think creatively in every activity.

As mentioned by *SG114*,

"I am motivated to be active while learning. I also must think creatively because we do every activity in groups. If I'm passive, I won't be able to give a creative opinion, and I might burden my team members" *(SG114)*.

Communication Skills

The learning activity planned in the CT-STEM module required active communication between students. Such requirements indirectly forced the students to communicate in groups or between groups through collaborative learning. The students were trained to communicate with their peers through collaborative learning. They were encouraged to ask their teammates or other teams when solving a problem. Each student conducted each activity in groups. *SG82* asserted,

"Working in groups has improved my communication skills. It forced me to talk. I had to think more creatively from every perspective to give ideas to my group" *(SG82).*

Creative learning could increase the quality of communication skills and the confidence to voice opinions and ideas. This strategy also encouraged communication, especially while constructing the prototype, answering group worksheets, and during the presentation. *SG85* reflected,

"While teaching, the teacher asked questions and our opinion, and then, there's the presentation session. I had to think creatively and talk. I hope learning such as using the CT-STEM module can be held again because I'm always afraid to give my opinions, and I do not have the chance to give a creative and interesting idea without this motivation. Learning like this could improve my communication skills and make me more creative" *(SG85)*.

Based on the data analysis of the open-ended questionnaire, most students (43) believed that learning using the CT-STEM module increased their confidence in their abilities and allowed them to communicate effectively.

Humanity Skills

Based on the analysis of the group work, the researchers found that each group tried to answer the questions in the worksheet provided. The students provided creative and relevant answers during the group discussions. In this regard, the discussions with group members and the great teamwork indirectly improved the students' humanity skills. Some of the skills observed were respecting others' opinions, working together, appreciating nature, and compromising. The students could also organise group work division strategies so that the group activities could be implemented smoothly within the given timeframe. The following passage illustrates the situation:

"These types of learning make me and my friends able to help each other. If my work is done, I will help my group members so that our group work can be done successfully" *(SG818)*.

"To me, working together is what we always do; it can improve our bonding and hear others' opinions" *(SG118)*.

From the students' reflection records, the researchers found that they could master more humanity skills which were very important for them in their working environment and life after graduating.

Discussion

This study aimed to investigate the effects of the CT-STEM module on high school students. In this study, we focused on using various creative learning strategies in STEM education, including problem-based learning, project-based learning, constructivism learning and discovery inquiry, by applying the student-centred constructivist theory in the CT-STEM module. Many studies related to STEM education focused on students' creativity development (Chen & Chen, 2021; Purwadi, 2021; Sirajudin et al., 2021; Weng et al., 2022). Yet, previous studies placed less emphasis on applying various creative teaching strategies in STEM education.

The module applied in this study created an active learning pattern that positively impacted students' thinking skills development. Carlson and Winquist (2011) discovered that the active learning approach affected cognitive competence. Consequently, STEM learning could improve creative and critical thinking, leading the students to solve problems effectively using whole-brain skills (Utamni et al., 2021). This aligned with the findings in previous studies, which discovered that creative STEM-based activities improved problem-solving skills (Maegala et al., 2021; Purwadi, 2021; Utamni et al., 2021; Wahono et al., 2020). At the same time, conducting STEM-based activities requires an analytical approach which encourages students to apply a high level of thinking (Sukardi et al., 2021). In contrast, Rasul et al. (2018) stated that STEM-based interventions' effects on creativity were due to the disciplinary aspect integrated within STEM education. Based on our study, we agree that integrating STEM elements is an important factor in developing students' creativity. However, a creative teaching approach is also needed as a catalyst to increase students' creativity. Meanwhile, Weng et al. (2022) suggested that the teaching pattern must include non-cognitive characteristics, such as interests and students' identity, to increase cognitive competence and critical thinking.

The students' learning activities through CT-STEM learning forced the students to participate in group work, encouraging collaborative learning. We found that collaborative problem-solving tasks encouraged the student's involvement in all levels of learning, developing 21st-century skills in students. Marcelo et al. (2021) stated that creativity and collaboration were important skills to revolutionise education. A previous study proved that collaborative problem solving based on STEM could increase opportunities to spark students' creativity (Michalsky & Cohen, 2021), conferring many benefits, such as making students more responsible towards themselves and their peers (Pinasa & Srisook, 2019). Another study related to the engineering field discovered that creativity was a necessity in engineering design instead of an accessory (Carlos et al., 2019; Purwadi, 2021; Sasangbong & Huntula, 2022). Pinasa and Srisook (2019) and Weng et al. (2022) agreed that STEM education should emphasise the innovation and creativity needed to solve real-life problems.

In this study, we found student-centred creative teaching more interesting, contributing to the students' positive motivation. This statement was also aligned with the report by Barry et al. (2018): creative teaching is important to motivate and attract students' interest in continuing academic studies in the STEM field. This study showed that a creative teaching strategy involving a student-centred learning environment made STEM education more interesting and positively motivated students. With the presence of motivation and a positive attitude, the students would try to understand the learning materials before and while the class is being conducted through group discussions and put more effort into understanding difficult concepts (Bateiha et al., 2020), indirectly improving the soft skills within students. A previous study by Purwadi (2021) proved that a good learning environment in STEM education could not only increase students' enthusiasm and motivation but also indirectly improve students' performance and achievement in the STEM field. With a mutually supportive learning environment among students, better emotions in learning can improve the student's critical thinking, fostering interests in the STEM fields and positive identity values.

The interventions performed in this paperwork proved that creative teaching with various strategies, such as the CT-STEM module, was needed to implement STEM education to support the development of cognitive and non-cognitive competence. The study's findings suggest that creative teaching activities provide opportunities for students to develop creativity through better innovation and practising new ideas without neglecting various other skills, especially communication and soft skills. Tunkham et al. (2016) also agreed that humanity could be improved through STEM-based activities, which promoted and interacted with the users' abilities, such as creativity, critical thinking, and teamwork. The humanity skills in solving environmental issues indirectly culminate in students when the students are aware of their duties, professional responsibilities, and ethics as environmental engineers (Wilson, 2019).

Conclusion

The modernisation has affected STEM education, and teachers must be creative by using various interesting approaches. The result of this research helps the teachers and related parties to implement CT-STEM education in the future. STEM educational programmes must have various creative learning processes to increase students' interests in science, technology, engineering, and mathematics. In this research, the researchers provided different CT-STEM activities in one module, which applied four different learning approaches: constructivism, discovery inquiry, problem-based learning, and project-based learning. This study has shown that the CT-STEM module can be used as a source of teaching materials in STEM education.

Furthermore, creative teaching strategies can train new and novice teachers to help them diversify their teaching methods to achieve the learning objectives. Meanwhile, regarding the implications of these activities for students, they can improve five main and necessary skills: problem-solving skills in STEM and sustainability issues, high-level thinking skills, active learning skills, communication skills, and humanity skills. By making STEM more practical, working in groups enables students to obtain a deeper understanding of learning concepts that they experience through discussions, discovery, applying knowledge in the real world and working together to create a prototype. From this experience, students can improve cognitive and social abilities, especially in the working field, and the skills required in societies.

Recommendations

This study puts forward several recommendations for further research on creativity in STEM education, including the education for sustainable development. First, future researchers could examine various themes related to sustainable development. Possible themes include vehicle sustainability, infrastructure sustainability, and wireless system sustainability. These themes should be introduced to students because nowadays, they are highly exposed to various technological sophistication. These topics give them the awareness to become smart users to ensure the preservation of the world. Besides that, issues like the teachers' lack of references in applying a creative approach to STEM education and sustainable educational development should be addressed. This study also suggests further research on the creative approach in STEM education to integrate STEM-based skills with robust literacy development for elementary school students. It is necessary to encourage students' interests in STEM and improve their awareness of STEM-based skills development. Third, mixed methods studies (qualitative and quantitative) are critical to examine students' creativity in STEM education to provide more comprehensive information and results.

Limitation

This article focused only on high school students taught using the CT-STEM module under the theme of 'energy sustainability' and were involved in outdoor activities. This study only focused on Form 2 and Form 4 students involved in STEM education activities. Thus, future studies should involve students from various, if not all, grades to increase the reliability and effectiveness of the developed modules. This is because creative teaching and learning in STEM education are important for students of all levels. Finally, the number of students involved, the assignments given, and the student learning environment was limited as the study was conducted in only one school and involved a small number of students. Therefore, a larger scale study can be conducted to obtain more robust findings.

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Authorship Contribution Statement

Othman: Drafting manuscript, conceptualisation, design, data acquisition, analysis, & writing manuscript. Iksan: Editing, reviewing, supervision, & approval. Yasin: Reviewing, securing funding, supervision & final approval.

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