Malaysian Science Teachers' Needs for a design Thinking-Based STEM Module in year four Physical Science

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ABSTRACT

In the present day, integrating science, technology, engineering, and mathematics (STEM) education is seen as crucial in preparing students with 21st-century skills. However, in the real situation, the primary school teachers in Malaysia often face challenges, including insufficient resources and a lack of effective teaching strategies, which hinder their ability to foster critical and creative thinking in students. Hence, this study explores the needs of teachers and students from the teachers' perspective for the development of a design thinking-based STEM module in physical science for Malaysian Year Four students to address these challenges. Using a qualitative research design, data were collected through semi-structured interviews with five science teachers to identify the needs for the module development. Thematic analysis was used to analyse the data and revealed two key themes, namely, Fostering Effective Teaching and Assessment in Design Thinking STEM-based Modules and Developing Critical and Creative Thinking in Students. These themes emerged through categories such as teacher development and support, ICT adaptability, the integration of design thinking in STEM, and the cultivation of critical and creative thinking skills among students. The findings of this study highlight the needs for designing a module to equip students with higher-order thinking skills and prepare them with problem-solving skills. This research contributes to the growing body of literature on innovative science education with better pedagogy and offers potential insights for teachers in making their science lessons more meaningful.

Keywords: Design Thinking, STEM education, Science Learning, Needs Analysis, Learning Module

INTRODUCTION

Science education is a crucial component of 21st-century educational practices. The implementation of 21st-century practices requires teachers worldwide to lead the development of learning objectives that align with their teaching competencies. Hence, teachers are putting effort into creating wonders in their classroom. However, it is notable that there are teachers who want to give all out for their students but are hindered by common issues such as lack of resources and effective teaching methods. To address such issues, researchers need to study and suggest appropriate resources for the teachers to conduct instructional process to the extent where society is expecting for. One of the ways to help the teachers is to prepare suitable and reasonable modules that emphasise the integration of design thinking. Design thinking is highly recognised for its essence in harnessing problem-solving skills. Regardless of the

students' learning standard, problem-solving skills are closely linked to higher-order thinking skills, particularly emphasizing critical and creative thinking.

Based on Ladachart, Radchanet, Phornprasert, and Phothong's (2023) research on design thinking as a way to improve teaching and learning, it is an approach that uses human-centred design to help people develop their critical and creative problem-solving skills and their ability to make big changes. In other words, human-centric design is important in education because it helps students develop their creative confidence, which is resilient and incredibly positive. Therefore, by integrating the five steps of the learning process, this method of thinking is the best approach to discovering a human-centric solution (Malele & Ramaboka, 2020). According to research by Lor (2017) and Padzil, Karim, and Husnin (2022), teachers who use human-centric design in the classroom report that it encourages students to be creative, innovative, problem-solving, and collaborative, all of which are thought to be crucial for learning in the twenty-first century.

The teaching of science, particularly complex concepts like light, presents unique challenges for educators. As the educational landscape shifts towards student-centred and inquiry-based learning paradigms, understanding these challenges becomes essential for improving educational outcomes. This article presents the findings of a thematic analysis that highlights the needs and opportunities in science education, focusing on the integration of design thinking and student-centred learning.

According to Jamaludin, Fah, Khan, Hoon, and Yee's (2020) research, there is a need for additional learning modules on science topics such as energy and electricity. Finding an appropriate learning module for elementary science courses is seen to be challenging. Thus, it is notable to create a high-quality STEM module based on design thinking (Jamaludin et al, 2020; Padzil, Karim, & Husnin, 2021).

STATEMENT OF PROBLEM

Every student needs to develop critical thinking and creative problem-solving skills, which should be emphasised in science lessons since they help students think more critically, which in turn helps them deal with problems in everyday life (Raflee & Halim, 2021; Xing & Fadzil, 2021; Osborn, 1954). Aziz, Siraj, Darusalam, and Ladin (2019) asserted that every learning resource for students should incorporate tasks that harness critical thinking. However, Aziz et al. (2019) claimed that it is difficult for teachers to incorporate critical thinking into physical science lessons, and students also encounter this difficulty, which ultimately leads to their inability to think in a higher-order way. According to Yew, Lian, and Meng (2017), students in primary schools are often evaluated only using the contents in the textbook, and their ability to think and solve problems is confined to what is limited in the textbook.

Teachers play a vital role in helping students become proficient in the physical sciences by helping them develop their critical thinking and creative problem-solving skills (Raflee & Halim, 2021). Nevertheless, pedagogical knowledge and content knowledge are always intertwined with teachers. The other will not be commended if one of these is lacking. So do the methods of instruction and the function of the teacher in the science classroom.

On the other hand, students' education needs to change from conventional to thinking-based. In order to meet the needs of 21st-century learning, teachers need to go beyond traditional classroom-based instruction and create thinking-based learning that includes higher-order thinking skills (Karpudewan & Meng, 2017; Malele & Ramaboka, 2020; Xing & Fadzil, 2021). Thinking-based learning should replace traditional content delivery "at" students since it is no longer effective and helps students see and comprehend real-world issues. In such a situation, science classrooms should promote learning that is based on critical thinking and creative thinking in problem-solving. Teachers play a vital role in helping students become competent in the physical sciences by helping them understand the importance of critical and creative thinking in problem-solving (Raflee & Halim, 2021). Therefore, teachers should constantly integrate their pedagogical and content knowledge. It takes more than just

teachers' content knowledge of physical science to produce high-achieving students; they also need to be able to communicate their knowledge in a systematic manner.

Long ago, Trumper (1998) claimed that many teachers and students were not interested in science-related subjects and had very low scientific literacy in the physical sciences. If so, this would be regarded as a serious issue since teachers who are not very knowledgeable about science might use a didactic approach rather than one that is focused on the needs of the students (Daniel, 2013). According to a Ministry of Education report in Malaysia, only roughly half of physical science classes are taught in an innovative and successful manner (Kementerian Pendidikan Malaysia, 2013). According to studies, teachers' physical science lessons were primarily focused on delivering content to meet syllabus requirements rather than emphasising students' critical thinking and problem-solving skills (Murugayya & Nachiappan, 2022; OECD, 2009; OECD, 2015). Since over 50% of science teachers will likely remain in their positions for the next 20 to 30 years and undoubtedly use the same didactic approach in the science classroom, if this issue persists in our nation, the results of the teaching would have a negative impact on our scientific community (Kementerian Pendidikan Malaysia, 2013).

According to research on cognitive engagement by Yassin, Tek, Alimon, Baharom, and Ying (2010), Malaysian teachers talk more than they allow their students to, which ultimately prevents the students from thinking. The study found that 97.3% of teachers talked a lot, which is indicative of a strong didactic approach. It also specifically addressed the fact that Malaysian science teachers tended to use a teacher-centred approach rather than a student-centred one (Yassin et al., 2010). In addition, Yassin et al. (2010) found that the majority of Malaysian teachers ask lower-order thinking skills-based questions that place more emphasis on recalling scientific facts. In summary, students who engage in such rote learning practices will ultimately struggle in the scientific community due to their lower cognitive order, especially when learning science (Daniel, 2013).

However, overcoming these issues is not as simple as it may seem. Harnessing student-centred learning from teacher-centred can be another issue to face, as the greatest number of teaching resources in science learning are focusing on merely STEM content delivery instead of focusing on critical and creative thinking in problem solving (Honey & Hilton, 2011; Keiler, 2018). Students are to be spoon-fed with a mere cookbook-style module rather than encouraged to think independently to solve problems critically and creatively. To the extent of the knowledge of the researcher of this study, it is known that there is too little module for year four students specifically in fostering design thinking-based STEM skills that highly incorporate the higher-order thinking skills that are critical and creative thinking skills.

RESEARCH OBJECTIVES

This study was aimed at exploring the needs of science teachers for effective teaching and assessment using the design thinking-based STEM module for year four students. Hence, this paper will focus on achieving the following objectives:

i. identify the emerging theme pertaining to the needs of science teachers for effective teaching and assessment using a design thinking-based STEM module.
ii. identify the emerging theme pertaining to the needs of students based on the teacher’s perspective for effective teaching and assessment using a design thinking-based STEM module.

RESEARCH QUESTIONS

This paper will address the answers to the following questions:

i. What is the emerging theme pertaining to the **needs of science teachers** for effective teaching and assessment using a design thinking-based STEM module?
ii. What is the emerging theme pertaining to the **needs of students based on teacher's perspective** for effective teaching and assessment using a design thinking-based STEM module?

LITERATURE REVIEW

Design thinking is relatively very new in education, especially in science education (Purwasih, Wilujeng, Wiyarsi, & Zakwandi, 2024) and its benefit in science classroom is less clear (Ladachart, et al, 2023). Design thinking in education is a dynamic approach that emphasises creativity, collaboration, and problem-solving. It involves a structured process that helps students and educators tackle challenges by:

i. **Identifying Problems**: Understanding and defining the problem or challenge.
ii. **Gathering Information**: Researching and collecting relevant data.
iii. **Generating Ideas**: Brainstorming and coming up with potential solutions.
iv. **Prototyping**: Creating models or prototypes of the best ideas.
v. **Testing Solutions**: Evaluating and refining the prototypes based on feedback.

By integrating design thinking into the curriculum, educators can create learning experiences that are both engaging and effective, preparing students for real-world challenges.

Research indicates that when educators adopt design thinking methodologies, they can significantly enhance student engagement and learning outcomes (Wu, Hu, & Wang, 2019). However, despite the potential benefits, teachers often encounter challenges in implementing this method. Wu, Hu, and Wang (2019) highlighted the gap that exists between educational theory and practice, revealing that many teachers should scaffold students with learning materials to integrate innovative design thinking methods into their classrooms. Despite the recognition of this gap, the effective integration of innovative design thinking methods is often hindered by the scarcity of teaching and learning resources and the lack of institutional support.

Teaching resources have been in the hunt when it comes to teaching. However, the lack of teaching and learning resources as well as institutional support further complicates the adoption of 21st-century practices (Honey & Hilton, 2011). Besides that, it is notable that there has been a lack of teaching and learning materials that incorporate the design thinking framework for the younger students in Malaysia (Ismail, Fadzil, Saat, & Salleh, 2022; Jamaludin et al., 2020). Student-centred learning is also crucial in contemporary education, while promoting active learning environments that foster critical thinking and creativity (Boge, 2012; Combs, Cennamo, & Newbill, 2009; Evans, 2020), however, there is insufficient learning module for students in science classrooms (Ahmad & Siew, 2022). Research demonstrates that inquiry-based learning strategies can lead to improved student understanding and retention of complex scientific concepts (Antonio & Prudente, 2024; Sam, 2024). Ladachart et al. (2023) asserted that teaching resources using design thinking-based learning is less clear in science education.

The key to improving students' understanding and retention of complex scientific concepts lies in supportive STEM integration. Ahmad and Siew (2022) developed a scientific learning module on entrepreneurial science thinking, which emphasises thinking in STEM education. When Ahmad's and Siew's work is compared to earlier research, it is evident that even if a number of modules have been produced for a long time, there are still issues with students' cognitive abilities. As a result, this problem encourages future researchers to continue creating modules in the hopes of filling in the gaps.

METHODOLOGY

This study employed qualitative research methods. The purpose of employing qualitative method is that the researcher could obtain open responses about what is being practiced in science classrooms and what are the needs required by the teachers. Besides that, the qualitative approach is a very powerful way to obtain rich data from respondents (Ismail et al., 2022) because during interviews, the respondents are open to saying what they have in mind rather than confining their responses into a survey form.

For the purpose of the needs analysis, the researcher developed an interview protocol for the teachers comprising twenty-seven items. The twenty-seven items in the interview protocol were divided and put into six main sections, namely, general experience, design thinking in science classrooms, critical thinking skills, creative thinking skills, problem-solving skills, and expectations and suggestions. To ensure the consistency and accuracy of the interview process and data collection, the reliability and validity of the interview protocol are essential for maintaining the rigour of qualitative research. Hence, to ensure how well the interview questions could measure what the present study intends to obtain, the researcher has referred the initial interview protocol to two science education experts who are lecturers from two different institutions, respectively. The comments and suggestions given by the experts were very useful for the researcher to amend the initial interview protocol. A final interview protocol, taking into consideration all the reviews and suggestions from the experts, was then given to a researcher's peer to check how well the interview questions could be understood by the respondents. Table 1 shows the partial items in the interview protocol. The peer was able to understand the items in the protocol; hence, the researcher administered it to the respondents.

Table 1: Items in the interview protocol

Item Number	***Section***	***Item***
1	General Experience	Based on your experience in teaching science to year four pupils, which physical science topic(s) is seen the most difficult to teach and the toughest for the pupils to learn?
5	Design Thinking in Science Classroom	How do you think that there is a need to integrate design thinking in science classroom?
10	Critical Thinking Skill	In your opinion, is there a need for a design thinking-based STEM Module to be prepared for the teachers to teach students to acquire critical thinking skill? Why?
14	Creative Thinking Skill	How many of design thinking-based STEM Module in physical science have you used that helps students to acquire their critical and creative thinking skill for problem solving?
16	Problem-solving Skill	In your opinion, is there a need for a design thinking-based STEM Module to be prepared teachers to teach students to solve problem critically and creatively? Why?
24	Expectations and Suggestions	What are the contents of the physical science need to be emphasised in the module?

The participants for this study were five science teachers from three different schools at Kinta Utara District, Perak Darul Ridzuan, selected using convenience sampling. Although convenience sampling is not much preferred by other researchers, in this study, it was the most suitable because the process of selecting the teachers was mainly based on their availability, willingness, or practical ease of contact (Galvan & Galvan, 2017). All five teachers are well-trained in science education with a minimum

qualification of a bachelor's degree from local universities and teacher education institutions. All of them have teaching experience of more than ten years. Table 2 shows the summary of the participants.

Table 2: Summary about the participants

School (Anonymous)	***Teacher's Name (pseudonym)***	***Qualification***	***Teaching Experience***
School A	Ramlah	Bachelor's Degree	25 years
	Elisa	Masters	12 years
School B	Jeniffer	Bachelor's Degree	23 years
	Janaki	Bachelor's Degree	16 years
School C	Raju	Masters	20 years

Prior to meeting them personally, the researcher has obtained relevant permission from the Education Planning and Research Division (EPRD), State Education Department of Perak State (JPN Perak), and the school headmasters. The teachers were briefed with a consent letter to take part in the interview. Despite meeting and briefing approximately eleven teachers with consent letters, only five agreed to participate in the interview. The other six teachers have declined the request to take part in the study due to various issues, such as teachers having school programs, not being ready to be interviewed, having too much work to be done, and not being willing to stay a little longer after school hours for the interview session. Despite only five teachers participating in the interview, the researcher believed that in-depth interviews could yield rich data. To protect the privacy of the teachers, schools, and ethics of research, all five teachers and their schools' names have been kept anonymous by assigning a pseudonym to each (as shown in Table 2).

Data Collection

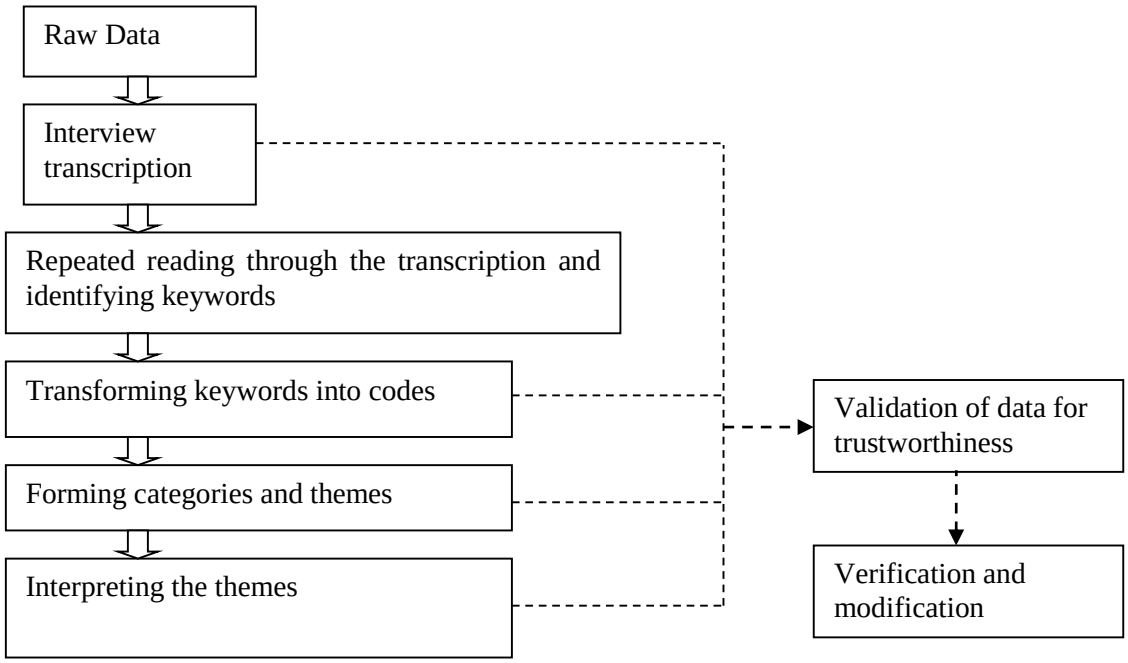
The interview protocol was administered individually in a one-to-one in-person interview to all five teachers after the school hours on different days. The researcher was informed by the headmasters of the schools that no teachers can be called for the interview session during their instructional time or any other time that the teachers are involved in any official duty. Hence, to comply with the order from the headmasters, the researcher obtained the teachers agreement to conduct interviews after the school hours. These schedules have minimized potential disruptions to school programs and ensured no disruptions during instructional hours. In addition, all the teachers were free to perform other official duties after school hours. Therefore, they were willing to allocate about an hour for the interview session. Each interview session took between 34 and 40 minutes. The interview sessions were recorded using a voice recorder on a smartphone, and all the recordings were then transferred to a laptop for transcription. The respondents seemed comfortable being interviewed and recorded, as it did not involve any extra tasks, and they were assured that no personal data should be revealed to anyone except for what was needed for the study, considering ethics. Prior to the interview, the respondents received a set of interview items for familiarization. Having the interview items beforehand, they were prepared for what to say during the interview session rather than having too many irrelevant responses and pauses. This helped the researcher to save the interview time and put no discomfort on the respondents. Hence, the respondents were quite comfortable with the researcher throughout the interview session. Following a successful interview session, the researcher saved the interview audio for analysis purposes. The audio files were then played in a quiet environment using headphones, and the respondents' speech was transcribed into text using word processing software.

Data Analysis

To analyse the interview data, an inductive thematic analysis approach was used independently as suggested by Galvan and Galvan (2017). Adopting an inductive approach benefitted the researcher, as

inductive thematic analysis is data-driven, allowing themes to emerge naturally from the data set without being influenced by the researcher's theoretical commitments or preconceived ideas. This approach is highly flexible, accommodating various types of data and research questions, as it is not confined to any specific theoretical framework. Due to training constraints in using thematic analytical software and time constraints to learn the software from scratch, the researcher practiced the manual coding process using tabulation in word processing software. Upon the transcription of the interview, the researcher proceeds with coding. Hence, a coding framework by Creswell (2014), as shown in Figure 1, was used to analyse the data in a well-organised way. To obtain initial codes, the researcher read the transcription repeatedly several times to understand and get better insight into what is being said by the respondents. Braun and Clarke (2006) recommended that repeated listening and reading will strengthen the researcher's connection with the data, which can help develop themes for further analysis. From the repeated reading of the transcription, the coding process took place. The initial codes were identified from the transcription, represented in keywords and highlighted using four colours, namely, red, blue, green, and brown for alarming issues, non-alarming, teacher's needs, and students, respectively. All the identified codes were then placed into a table chart for proper categorisation. In the next step, the themes were interpreted by emphasising both the possible parallels and discrepancies in the data that had been transcribed. The process of developing themes continued until the data was saturated. Upon the development of themes, the researcher asked the respondents, who are the participants, to provide feedback on how accurately the researcher perceived the respondents' speech. Galvan and Galvan (2017) and Braun and Clarke (2006) asserted that member checking by obtaining feedback from the participants is crucial in a qualitative study setting to sustain the idea put forward by the participants. To validate the data, the researcher's colleagues, who are also science teachers and experts, cross-checked (peer review) the transcripts and codes. To boost confidence in the findings, consultation through peer review is particularly crucial when a researcher has carried out the study alone (Galvan & Galvan, 2017).

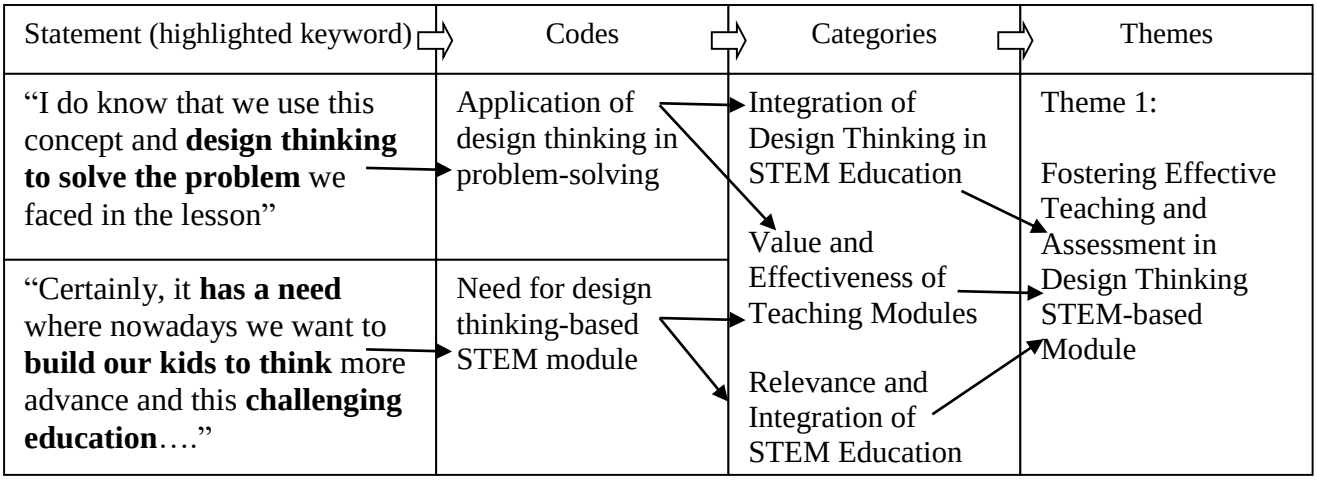
Figure 1: *Coding Framework (Adapted from the work of Creswell, 2014)*



The coding process was conducted manually using inductive thematic analysis. This paper is intended to discuss the needs for the development of a design thinking-based STEM module in physical science. Hence, only partial data will be released for the purpose of expressing how the themes were derived. Each code obtained from the transcripts was tabulated in alphabetical order to avoid repetition. This helped the researcher to collapse the initial codes and lead to categorisation in an organised manner. Similar codes were organised into one column prior to categorisation. The categories that emerged were

created by collapsing and condensing similar and overlapping early codes. After that, the categories were further condensed and merged into final themes. After that, the researcher submitted a copy of the categories and themes to the peers for peer review. In this study the peers were also science teachers who have teaching experience of more than 20 years. Peer review was considered essential to prevent the study from being prone to the Hawthorne effect and unclear categories (McCambridge, Witton, & Elbourne, 2014). Figure 2 shows the example of how the themes were derived.

Figure 2: Example of how the themes were derived



FINDINGS AND DISCUSSION

The interview transcripts from five respondents provided tremendously rich data. Although the interview items were prepared to elicit teachers' opinions and needs, the successful coding process allowed the researcher to develop five themes to support the development of the design thinking-based STEM module. However, three of these themes emerged during the ongoing analysis process. In this paper, the researcher will discuss only the two main themes that address the needs of science teachers to support the module development process.

The first theme that will be discussed in this paper is **Fostering Effective Teaching and Assessment in Design Thinking STEM-based Module**. To finalise this theme, there were eight categories involved whereby all of them were condensed. To further explain the first theme, it is crucial to elaborate on the categories that became the building blocks of the mentioned theme, which are:

Integration of Design Thinking in STEM Education. This category highlights the use of design thinking as a method for addressing challenges faced in lessons and the perceived necessity for a structured module to support the integration of design thinking in STEM education. To the extent of literature search using recognised publishers, journal articles indicate that knowledge of design thinking was often benefitted in businesses, but in education, it is not fully benefitted or even not directly applied in science education, especially in the year four science syllabus in Malaysia (Long, 2012). The interviews that were conducted for this study emphasise the importance of strategic planning when implementing design thinking in the year four science classroom. The respondents view emphasises that the process of idea generation, production, and testing in the context of design thinking must be included in the learning process, particularly for the young learners. Similar to what Long (2012) asserted, the present data also revealed that the context of design thinking in education can be a vital element not only to harness the needed 21st-century skills but also to help the students learn and collaborate to think critically and creatively to solve problems. Besides being the support module for the students, the teachers could also increase their potentiality in boosting their instructional process through the design thinking module in the science classroom. The following excerpts by the respondents

obtained from the interview transcription support the claim to integrate the essence of design thinking for the year four students through a STEM module.

"But I do know that we use this concept and design thinking to solve the problem we faced in the lesson"

Elisa, Item 4 Line 2

"To answer this question, I am familiar with our design at design thinking is not in science but in RBT but it can be applied in science. It's just that it needs careful planning"

Ramlah, Item 4 Line 1

Enhancing Teacher Development and Support. The crucial focus in the teacher development process is indeed the practice that needs to be enriched with the right aids and representations. The excerpts reflect the belief among the science teachers that having a module with the integration of design thinking would enhance the teacher's ability to conduct activities effectively and responsively. Besides that, there is a need to capture the teacher's aspiration to improve their teaching skills and practices, which would lead to better quality of teaching. Likely mentioned by the respondents is that they need a module not only to increase the learning experience for students but also to emphasise the potential presence of the module to contribute to teachers' ongoing learning and improvement. The following excerpt emphasises the need for resources that enable teachers to adopt innovative approaches in their classrooms as part of their instructional skill development.

"I think without a doubt I agree to have a module because somehow this module can help the teachers' burden. And this module will also help the teachers to improve themselves better"

Elisa, Item 20 Line 1

"Agreed, because it can also help teachers because they can understand concepts more clearly. Not all teachers understand. I sometimes understand and don't understand. When there is this module, you can guide the teacher so that he does not run away from the focus."

Ramlah, Item 20, Line 1

Furthermore, the study revealed that teachers express a desire for resources that concentrate on improving their effectiveness and time management skills. Less known by the respondents is that the design thinking-based module could highlight the importance of resources for teachers who are new to certain methodologies. Certainly, the respondents who are also well-trained teachers hope to have a module to help them improve their skills and teaching practices. The excerpt below shows that the respondent not only desires to generate the students' skills but also to design an intriguing learning process.

'I agree to have module that has open questions to elicit critical and creative thinking so that it can generate students' thinking skills at a high level and it can also help teachers in the preparation of interesting lesson"

Jeniffer, Item 20, Line 1

Improving Assessment, Practices and Resources. This category reflects the need for precise and accurate assessments in evaluating student performance. Besides harnessing an engaging lesson, it is a core element for a teacher to strengthen the students' assessment process. Parallel to that, the findings in this study emphasise the role that teaching modules could play in improving the fairness and accuracy of assessments given by the teacher in the science classroom. Having said that, the need to focus on the

potential of the intended module must be taken into account to improve the quality and reliability of assessments. The issues that the respondents highlighted were the desire to avoid bias when assessing students. In this study, Elisa and Ramlah mentioned openly during the interview that they need a module to help them to assess accurately and precisely without bias, especially for the weak and passive students. The following excerpts depict the earlier claim.

"I think it's better good to have a module because as a teacher we always can assess the kid accurately or precisely and without bias"
Elisa, Item 18, Line 1

"In my opinion it is necessary. It's just that it's quite difficult for students who are weak or lack exposure and also passive students"
Ramlah, Item 18, Line 1

Having a module in a science classroom can encourage the use of straightforward tests as part of the assessment strategy, which reflects the use of projects as a method to evaluate students' understanding and their thinking skills. As for the aim of this study, it is highly expected that it will also focus on assessing students' cognitive abilities, critical thinking, and creative thinking through design thinking. The following excerpts capture the practice of evaluating what students have learnt through various methods.

"I assess the kids using projects, I'll also use to give them simple test to test their thinking and what they have learnt"
Elisa, Item 17, Line 1

"Teachers can assess students through projects where students have to present projects or explain and state strong reasons why the project was created and its use in the future"
Jeniffer, Item 17, Line 1

"...we can say that we can assess the student's meaning that he understands because answering the question means that he understands what is to be discussed."
Ramlah, Item 17, Line 3

"To me, I will use simple projects to assess my students. If I use module also can, I think.it is difficult to see what level they think critically"
Raju, Item 17, Line 1

In order to apply good practice, several practices need to be put forward, such as the use of mind maps to help students visualise and organise their ideas. Effective practices suggest using examples to help students visualise concepts and improve their ideas. Elisa and Ramlah similarly said that mind mapping and providing examples can be included in the intended module.

"I'll also will transfer their idea and facts to mind map once they have a clear picture so that they go to next step where they analyse and can make abbreviation on certain"
Elisa, Item 8, Line 2

In addition, teachers can also provide examples for students to compare or improve.
Ramlah, Item 8, Line 5

Besides that, the need for clear questions from teachers to facilitate critical thinking must be emphasised in the module. As part of the design thinking process, it is crucial to highlight the importance of group discussions in analysing information before decision-making. Contemporarily, the role of the teacher as more knowledgeable other in guiding and facilitating discussions needs to be accentuated.

"For critical thinking, the questions need to be clear, the questions from the teacher need to be clear so that the students can discuss in groups to analyse some information, the teacher's guidance is necessary"
Ramlah, Item 8, Line 1

Findings in this study also indicate that the clarity of a structured module needs to be developed in order to offer a clear picture to teachers during the assessment process. The data obtained revealed that the teachers believe in the role of a module in helping students to develop argumentative skills and make conclusive decisions using information critically and creatively. On the other hand, the module can facilitate better data analysis and evaluation as well as encourage deeper analytical and evaluative skills.

"To my mind, it is very important to have a module to encourage the data analysing, evaluation of arguments and making conclusion because as I said earlier module always going to give the assessor to have a clear picture"
Elisa, Item 22, Line 3

"In my opinion it is necessary… The STEM approach definitely helps the STEM module along with developing elements of critical and creative thinking"
Ramlah, Item 16 Line 1 and Line 4

Value and Effectiveness of Teaching Modules. During the interview, the respondents indicated the advantages of having organized materials that enhance teaching practices. They suggested that the module could help them with structured lessons in order to enhance the teaching process. Having an effective teaching module in the science classroom would emphasise the importance of maintaining a concentrated approach to teaching, especially for teachers who are lacking ideas.

"In my opinion, it will be better if we have module so if we can guide the teachers who don't have any idea regarding this…"
Elisa, Item 16, Line 1

"When there is this module, it will be more organized and focused."
Ramlah, Item 22, Line 1

Besides having a module for better teaching and assessment, developing a design thinking-based module for the teachers to use in the year four students' science classroom could help in easing the workload of teachers. The excerpts below support that the module can help teachers' burden to think of the right tools. Adding to that, it is believed that the module contributes to ongoing teacher development.

"I think without a doubt I agree to have a module because somehow this module can help the teachers' burden"

Elisa, Item 20, Line 1

"…And this module will also help the teachers to improve themselves better"

Elisa, Item 20, Line 2

The data obtained do reflect the belief of science teachers that structured modules could assist the teachers who are lacking experience or knowledge in making the teaching more creative and innovative. Elisa, in her interview, expressed that modules could help teachers to come up with innovative ideas.

"In my opinion, … and usually these modules will help the teachers to come up with their own or innovatively create their own idea"
Elisa, Item 16, Line 3

There is a need for the development of a module, and the suggestion put forward is that the module should be designed with ease of use and teacher comfort in mind. The excerpt below recommends having a teacher-friendly module.

"I hope all the module build can easily assess by the teachers because some teachers are good with ICT some are not so I hope all the module build is friendly"
Elisa, Item 25, Line 1

Support for Teacher and Student Needs. The respondents have expressed that developing a design thinking-based module with a STEM approach will be able to foster an environment where students can take an active role in their learning. The data obtained from the interview highlights the teachers' belief that design thinking can aid students in discovering their own learning processes and advance their higher-order thinking skills. As for the teachers, the intended module is expected to add potential advantages of integrating new teaching strategies, such as design thinking, into the science curriculum whereby students are able to link their prior knowledge with new knowledge. Hence, this emphasises the importance of using a Design Thinking-based STEM module in science education. Similar to what Kelly and Knowles (2016) and Dotson et al. (2020) argued, linking conceptual understandings and context in science classrooms using design thinking-based STEM activities could enhance the students' scientific knowledge and ability to solve problems critically and creatively. The following excerpts show that teachers believe the module could let the students discover themselves and understand the science content.

"…to build our kids to think more advance and this challenging education and I think ahh integrate this design thinking will help the kids to discover themselves and understand the content…"
Elisa, Item 5, Line 1

"…. If we do, we can just say that we need continuous help from the teacher to ensure that the journey goes smoothly because we have many topics to pursue…"
Ramlah, Item 5, Line 5

"…STEM module based on design thinking is necessary so that teachers can refer…"
Jeniffer, Item 10, Line 1

"I used to probe the kids with questions to trigger their previous thinking and current knowledge regarding this topic"
Elisa, Item 8, Line 1

"It means that what we give already exists, we only ask for improvement and that can help students in my opinion"
Ramlah, Item 8, Line 9

Adaptability and ICT Integration in module. Data obtained reveals that focus needs to be given on the importance of integrating ICT in a way that is manageable for all teachers in the design thinking-based STEM module. The respondents expected a module that can help students to use computers to enhance their learning. The respondents additionally expressed that the practice of using online resources to explore topics may strengthen students' understanding. Elisa and Ramlah emphasised that they use online platforms in their science classroom to enhance their students' learning. Jeniffer expressed that she uses videos from online platforms as a teaching tool to explain the concept of light. The expectation of the teachers is in parallel to the 21st-century teaching approach by having the application of technology in science education, similar to what Karupaiah and Daniel (2021) emphasised and the use of various technologies as a tool in teaching science is highly potential and demanding for creative learning (Ridzuwan, Halim, & Mohammad, 2024).

"I hope all the module build can easily assess by the teachers because some teachers are good with ICT some are not so I hope all the module build is friendly"
Elisa, Item 25, Line 1

"…usual way to overcome this problem is usually I take the students to the computer lab and show them how to use the computer…"
Ramlah, Item 3, Line 1
"I also often refer to YouTube which is closely related to the topic being taught…"
Jeniffer, Item 9, Line 2

Relevance and Integration of STEM Education. The respondents agreed on the importance of incorporating the relevance of STEM concepts to real-life experiences in the module to enhance the teaching and learning process. This category highlights the teachers' desire for a module that motivates and encourages students to ask questions related to STEM topics. A design thinking-based STEM module could enable students to apply their knowledge to explore and address challenges encountered in everyday life. By emphasising student-driven inquiry, the respondents underscored the need for a module that prioritises students initiating questions based on their own experiences and challenges. They also highlighted the importance of a structured module to support science teachers in delivering effective STEM education. The excerpts below reflect the integration of science, technology, engineering, and mathematics with real-life applications, fostering a learning environment that encourages student inquiry and engagement.

"I think the existing STEM module I used to encourage the kids the students to ask question because they can ask question regarding or based on the difficulties or challenges, they faced in the daily life"
Elisa, Item 12, Line 1

"…is an example of us applying PBL elements in using the STEM model"
Ramlah, Item 9, Line 6

The second theme that is glaring is the need and necessity of developing a module, as mentioned earlier, is **Developing Critical and Creative Thinking in Students**. Students' learning has always been the utmost priority of every teacher. The first theme mentioned was about the teachers' needs based on the teachers' point of view. While the second theme, however, depicts the needs that are crucial to put forward as the students' necessity based on the teachers' point of view. To derive the second theme, there were three categories outlined, namely, Critical Thinking for Students, Creative Thinking for Students and Students' Needs. The following justifications have been essential for the development of this theme.

Critical thinking for students. Ahmad and Siew (2022) highlighted the Malaysian education system's strong commitment to enhancing the curriculum by promoting Higher-Order Thinking Skills (HOTS), such as critical and creative thinking, at the primary school level. Similarly, the participants in this study highlighted the need for a module designed to cultivate HOTS among students. To foster critical thinking, the inclusion of open-ended questions in the module is essential, as these questions encourage students to reflect deeply on their understanding and articulate their thoughts and ideas effectively. Data from the interviews underscore the role of open-ended questions in stimulating continuous thinking and supporting students in developing their ideas. Therefore, incorporating open-ended questions is a key consideration in module development, as it fosters a problem-solving mindset and enables students to approach challenges more effectively. The excerpts below reinforce the necessity of clear, thought-provoking questions to facilitate critical thinking in the classroom.

"…giving open questions that can give, help students think continuously and can develop ideas. If we ask closed questions, the student's focus stops. So, make sure the questions given are open-ended questions…"
Ramlah, Item 19, Line 1

"In order to integrate critical thinking to the students, I ask high-level or open-ended problem-solving questions"
Jeniffer, Item 8, Line 1

"…I will help the kids to ask open ended question where that can motivate the thinking skill…"
Elisa, Item 11, Line 1

"…this approach equips students with the tools they need to become active and innovative…"
Janaki, Item 10, Line 3

Creative thinking for students. This category clarifies that the module must place emphasis on the goal of assisting students in analyzing information and creating abbreviations or summaries. This is to promote students' creativity in processing and presenting their ideas. Developing a design thinking-based STEM module focuses on encouraging students to create prototypes as a hands-on learning experience. Ramlah, in her response during the interview, suggested that the TVET approach also fosters creative thinking skills among students. Activities in the module must be ready to allow students' ability to contribute to solving problems collaboratively. Enhancing collaborative skills in the activities has a high potential to foster creativity through active learning. The excerpts highlight the promotion of innovative ideas and solutions among students.

"…The tvet approach definitely helps the stem module along with developing elements of critical and creative thinking…"
Ramlah, Item 16, Line 4
"…I will use a project-based learning to inculcate creative thinking"
Elisa, Item 13, Line 1

"…They have good idea and they can innovatively replace the materials and they also come up with the solution"
Elisa, Item 15, Line 2

Indeed, there is potential for a module that inspires students to come up with innovative solutions. Hence, the module should comprise elements of design thinking by focusing on students creating solutions that are environmentally friendly and sustainable. Open-ended questions play a crucial role in fostering argumentative skills and assisting students in developing their ideas. Nevertheless, Janaki, in her response, had stated that encouraging students to brainstorm various solutions for each problem is essential for creative thinking.

"…Ask students to argue for the points, then look into the structured problems, ok where they have rooms ok bring or come up with multiple solutions for each problem…"
Janaki, Item 21, Line 2

Students' needs. Students' needs are the utmost priority in every process of learning module development. The data enlightens us to focus on the experiential learning process where students analyse outcomes based on experiments. Learning collaboratively in the classroom ensures the importance of students working together in discussion groups, which emphasises the role of classmates and teachers in providing feedback during presentations. The needs of students should be a central focus in evaluating the constructive role of disagreements during discussions, as these interactions can enhance comprehension and critical thinking. Ramlah, through her response, indicated the opportunity for students to challenge each other's ideas and develop arguments must be placed as the highest priority. Hence, activities in the module should focus on peer collaboration, which highlights the importance of students working together in discussion groups. Students' learning using the module is required to foster active learning because it reflects the engagement of students in discussions and presentations to enhance understanding. The following excerpts justify the claim.

"In my opinion students can form discussion groups, can discuss and have a presentation… if there is an argument that other friends do not agree with and there may be a positive value added in the discussion"
Ramlah, Item 21, Line 1 & Line 3

"Kids usually analyse the data using the observation and the data collection while they get when they do the project or hands-on"
Elisa, Item 21, Line 1

Jeniffer, in her statement as below, expressed that students need empowerment because it highlights how knowledge of data analysis can empower them to take action in their daily lives.

"Data analysis can apply the use of data in the daily life of students. For example, monitoring the electricity consumption at home, they can analyse the data and can reduce the electricity bill in their home"
Jeniffer, Item 21, Line 1

While on the other hand, Janaki expressed that encouragement of exploration is essential through the importance of exploring questions deeply rather than settling for surface-level answers. Fostering argumentation skills among students in the module emphasises the role of asking students to defend their viewpoints.

"First thing, teach students to use advantages and disadvantages of the points and explore the questions"
Janaki, Item 21, Line 1

Supporting students in drawing conclusions explains the value of a module in guiding them toward making informed decisions. Hence, enhancement of critical thinking through modules for students focuses on how a module can encourage deeper analytical and evaluative skills. The codes identified emphasise the role of modules in enhancing data analysis and critical thinking among students. Enhanced understanding indicates the potential for improved comprehension among students, especially improving their comprehension of content through innovative methods. The following excerpts enlighten the students' need category.

"Certainly, it has a need where nowadays we want to build our kids to think more advance"
Elisa, Item 5, Line 1

"…it's very important to have a module to encourage the data analysing evaluation of arguments and making conclusion…"
Elisa, Item 22, Line 1

"…this module is important because it is a guide because it can help the teacher convey information accurately to the students and further help improve the students' understanding…"
Ramlah, Item 22, Line 1

"It is important because it's a process of learning to analyse critically evaluate the ideas, arguments and points of view"
Janaki, Item 22, Line 1

CONCLUSION

In the 21st century, science education plays an important role in shaping students' skills and competencies to address contemporary challenges. However, in science classrooms, teachers often face obstacles such as limited resources and ineffective teaching methods, which certainly hinder their ability to fully support their students to perform. Therefore, this study highlights the potential of a design thinking-based STEM module as a potential solution to these challenges. Lately, design thinking is picking up the pitch and being recognised for improving students' problem-solving skills, which align closely with higher-order thinking skills, including critical and creative thinking.

In this study, two main themes emerged, namely, Fostering Effective Teaching and Assessment in Design Thinking STEM-based Modules and Developing Critical and Creative Thinking in Students. These two themes emerged through the categories such as the integration of design thinking in STEM education, teacher support, adaptability of teaching modules, and the cultivation of critical and creative thinking skills in students. Hence, the findings of this study emphasise the needs for a design thinking-based STEM module in physical science for Year Four students, which is intended to enhance teaching effectiveness in science classrooms and meet the needs of both teachers and students.

Furthermore, a well-developed design thinking-based STEM module has the potential to empower teachers to equip their students with 21st-century skills, especially thinking skills. Eventually, upon acquiring the thinking skills, students could prepare themselves for a dynamic and demanding future. This study serves as a foundational step in bridging the gap between effective teaching practices and the holistic development of students in STEM education through the design thinking approach.

Although this study has discussed the needs of science teachers for a design thinking-based STEM module in physical science, it is highly recommended that future researchers should consider including the year four students' needs. Obtaining insights from the students' perspective could provide a more comprehensive understanding of their needs for better learning. Thus, the findings could further enhance the module's effectiveness and relevance.

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