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Need analysis: development of a teaching module for enhancing higher-order thinking skills of primary school students

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ABSTRACT

This research identified a pressing need to create specialized teaching modules for electrical topics within the science curriculum that target students' higher-order thinking skills (HOTS). Despite the recognized significance of HOTS in improving students' educational achievements, science educators encounter obstacles when attempting to effectively teach these skills. To tackle this challenge, the study utilized a qualitative research methodology, conducting semi-structured interviews with six science teachers from diverse Malaysian schools. The primary objective was to pinpoint the necessity for developing instructional modules that enhance students' HOTS in primary school science subjects. This study revealed four key themes arising from the needs assessment: the importance of HOTS knowledge, obstacles in teaching HOTS, effective teaching strategies, and the actual teaching of HOTS. This study underscores the critical need for enhanced professional development opportunities for teachers to effectively impart HOTS and stresses the importance of providing suitable teaching resources. By developing these tailored modules, students' critical thinking and problem-solving skills can be nurtured, paving the way for their academic and professional success. Consequently, the study's recommendations offer valuable insights for policymakers, educators, and researchers seeking to create impactful teaching modules that cater to students' HOTS in primary school science subjects.

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1. INTRODUCTION

In recent years, there has been much attention on effective science teaching strategies for student achievement [1]–[4]. Science education research has long focused on scientific higher-order thinking skills (HOTS). It has been recognized that students' HOTS plays a significant part in the science learning process [5]. HOTS refers to the ability to think on a higher level than remembering information or repeating something back to someone [6]. Science learning is characterized by conceptual understanding, involvement, and collaboration between students while conducting practical activities. HOTS allows students to learn scientific concepts and enables them to develop scientific literacy by involving them in scientific research [7].

Besides helping students pass exams, science also assists them in understanding and applying what they have studied. Several initiatives over the past 20 years have been made to overhaul scientific instruction in schools [2]. Teachers, as "change agents", can better comprehend, practice, and implement HOTS, such as critical thinking and argumentation skills, for science education reform to be successful. Teachers may be

smart and creative in choosing and developing effective teaching and learning techniques, and they can entice students to follow them. As a result, the teaching approach adopted can develop students' thinking skills by developing their preferences, abilities, and competencies. According to Yeung [8], teaching for developing HOTS is critical for preparing students to participate in and contribute to modern societies. Previous research has suggested that most students are uninterested in science courses, even though these disciplines have a significant association with their daily life [9]. One of the most challenging tasks for educational systems, including Malaysia's, has been to encourage students to continue their science education [10]. The problem of reduced interest in school science subjects is caused by various factors, including gender and age, primary school teachers' lack of confidence in teaching science courses, lack of subject expertise, lack of abstract thinking, and traditional teaching methods [11].

The Trends in International Mathematics and Science Study (TIMSS) is an international comparative study by the International Association for the Evaluation of Educational Achievement (IEA). The TIMSS study is conducted every four years, and the first TIMSS study was undertaken in TIMSS 1995. The studies offered by the IEA include TIMSS grade four, TIMSS grade eight, and TIMSS advanced. The Program for International Students Assessment (PISA) measures the literacy rate of 15-year-old students, especially in mathematics, science, and reading ability rate. Based on the report on the status of Malaysia's achievements in TIMSS and PISA in 2018, Malaysia is in the bottom 20 countries [12]. This result shows that Malaysia's achievements in TIMSS are still not something to be proud of [13]. Therefore, the current study aims to explore the problems and requirements related to developing teaching modules to improve students' HOTS in science subjects for the topic of electricity. The research is important because it addresses a critical need in the field of education, particularly in the development of effective teaching modules that cater to students' HOTS. The study's novelty lies in its focus on electrical topics under the science syllabus and its use of a qualitative research approach to identify the need for teaching modules that cater to students' HOTS. The study's findings can provide practical guidance for policymakers, educators, and researchers in developing effective teaching modules that enhance students' critical thinking and problem-solving skills.

2. LITERATURE REVIEW

2.1. The importance of science education

The development of science and technology has always been a feature of developed countries. Part of this achievement can be attributed to their ongoing evaluation and understanding of the science curriculum development. They aim to raise all age groups' proficiency levels in math and science [14]. Past researchers have placed a great deal of emphasis on the importance of science for employment, especially it is global significance in improving the socioeconomic status of the nation, ensuring the stability of technology, and improving the standard of science curriculum development [15], [16]. Nevertheless, several factors must be recognized to produce scientifically literate students interested in science to create a workforce of qualified professionals. Factors that affect students' interest in science must also be analyzed in terms of their learning criteria.

2.2. Issues in science education in primary schools

The most recent technology developments have the potential to transform the educational landscape. The development of multimedia and the Internet has given teachers and students additional opportunities to study and facilities to rapidly and easily access information and educational resources online [17], [18]. Yet, many students are unable to understand HOTS due to the traditional teacher-centered approach and the fact-memorizing phenomena [19], [20]. Consequently, mastery of HOTS among students is still low [21]. Teachers must develop teaching resources that are not just focused on one source to provide students with relevant HOTS experiences. This situation demonstrates the critical necessity for one of these guides to serve as a teaching module that focuses on implementing HOTS starting in primary school. Many primary school students are still struggling to grasp HOTS. To apply HOTS to students, useful lessons and methods should be used by teachers.

2.3. Science education and higher-order thinking skills

Helping students develop HOTS, which will enable them to think critically, ask meaningful questions, reason, and solve problems, is the main objective of science education [22]. The definition of HOTS includes the ability to produce complex, non-algorithmic, multiple solutions and make nuanced judgements and interpretations [23]. Metacognition is increasingly acknowledged as an essential component of HOTSs, according to Hainora *et al.* [24]. Furthermore, other studies have accepted the common perspective of 'HOTS about cognition' [25]. When HOTS is needed to address difficult challenges, people use various abilities to accomplish their objectives [26]. In science education, science self-efficacy influences

students' science-related activities as they experience success in science [27]. Metacognitive abilities have traditionally been seen as critical to the development of scientific reasoning because they provide the epistemological foundation, conceptual motivation, and cognitive control for individuals to employ underlying talents in science learning tasks [28].

3. METHOD

This study utilized the qualitative approach to gather data. More detailed information was gathered via semi-structured interviews [29]. Creswell and Poth [30] suggested that the appropriate minimum informants for a qualitative study were between three to seven people depending on the saturation of the data occurring during future studies. Yin [31] opinion presented that two to ten samples were sufficient to reach saturation. As a result, the sixth interviewee showed signs of saturation when the same themes were repeated with subsequent.

This qualitative study's sample consisted of six specialist teachers from six different schools. Six primary school science teachers in Negeri Sembilan, Malaysia, participated in focus groups. Six people were interviewed as part of the study, all of whom were chosen by purposive sampling. The criteria for selecting these teachers to be study participants were based on the importance of their personal and professional experiences and abilities to articulate and reflect on issues and challenges of teaching using various methods, such as virtual learning methods in teaching primary school science subjects. The participants of this study consisted of three male teachers and three female teachers. All participants must have an average of 5 to 25 years of full-time teaching experience in primary schools in Malaysia. Table 1 shows the demographic information of informants.

Table 1. Demographic information of informants

Informant	Sex	Age	Post	Teaching experience (years)	Education
T1	Male	45	Science teacher	25	Degree
T2	Male	45	Science teacher	25	Degree
T3	Male	43	Science teacher	22	Degree
T4	Female	40	Science teacher	18	Degree
T5	Female	42	Science teacher	19	Degree
T6	Female	41	Science teacher	17	Degree

3.1. Data collection process

In line with the existing literature, data collection was conducted through semi-structured interviews. Individual in-depth interviews were utilized to examine science teachers' perceptions regarding the development of a module aimed at enhancing HOTS and addressing challenges they encountered in the classroom. Each interview was conducted one-on-one, involving only the interviewer and the participant, and lasted an average of 45 to 90 minutes. Both verbal and non-verbal cues were captured through written notes and audio recordings. Participants were provided with interview transcripts for validation, feedback, and possible revisions.

Before conducting the research, the study protocol was approved by the Universiti Putra Malaysia (UPM) Ethics Committee for Research Involving Human Subjects (No. JKEUPM-2021-844). The researchers adhered to strict privacy principles when collecting and storing participant information. To ensure confidentiality, all identifiable data were anonymized during transcription using pseudonyms. Participants were provided with the transcriptions for their review and feedback. Voice recordings, transcripts, and interview notes were securely stored on a password-protected computer, with all data set to be destroyed five years after the completion of research and publication. The study followed a carefully designed protocol to ensure clarity of data and minimize researcher bias in the semi-structured interviews. The transcripts and findings were reviewed by team members for feedback. Participants gave written informed consent prior to their involvement in the study. Thematic analysis was applied manually, and an inductive approach [32] was used to analyze the data by reading the transcripts line-by-line to understand participants' experiences and develop themes. A constant comparison method was employed to refine these themes in relation to the diverse experiences of the participants [33].

4. RESULTS AND DISCUSSION

Analysis of the data revealed four major themes capturing the experiences of the study participants. An interview was conducted with six science teachers to examine the need to develop the teaching module. Four themes emerged from the need analysis, namely: i) the importance of HOTS knowledge; ii) challenges

in teaching and learning; iii) teaching strategies; and iv) teaching skills. Figure 1 shows the themes and sub-themes of the study.

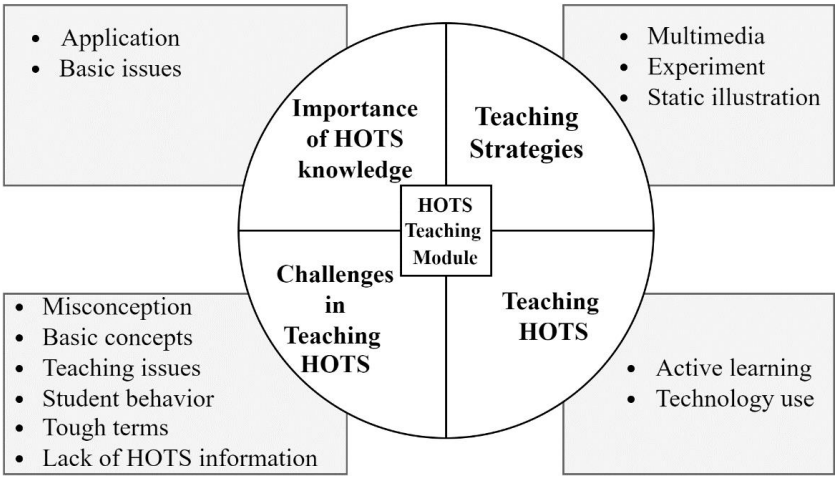

Figure 1. Themes and sub-themes of the study

4.1. Results

4.1.1. Theme 1: importance of higher-order thinking skills knowledge

All six teachers agreed that HOTS knowledge was fundamental to be mastered by students. Since science is the study of technology, the concept of electricity is essential to understand getting a clearer picture of technological progress. Quoting the words from teacher 5:

> "*It is important that students can apply the concept of electricity in the physics chapter while studying in secondary school later, and the knowledge of the teacher plays an important role.*"

According to teacher 1, it is vital to understand how electrical topics may be used and transferred to students so that they can utilize them in their future lives, such as when using electrical circuits [5].

4.1.2. Theme 2: challenges in teaching higher-order thinking skills

The six teachers expressed diverse perspectives on the challenges faced by students during instruction. Teacher 3 noted that, "*students cannot visualize the complete process of an electrical circuit*." Similarly, teacher 5 stated that, "*students struggle to grasp various terms related to electrical topics*." Four other teachers echoed this concern, identifying terms like serial circuit, parallel circuit, complete circuit, and green technology as particularly difficult for students to comprehend. Teacher 3 further explained that students found these terms challenging because they were introduced as entirely new concepts.

All six teachers agreed that most students were unable to apply the knowledge gained to complete HOTS tasks. Teacher 3 added that students also found it difficult to distinguish between series and parallel circuits. Additionally, student attitudes were highlighted as contributing to the learning difficulties in science subjects. For instance, students often refrained from asking questions during lessons. As teacher 5 remarked, "*teachers assume students understand the lessons because few ask questions*." Teacher 2 suggested that this lack of engagement could be attributed to students limited prior knowledge.

All the teachers concurred that this reluctance to ask questions negatively impacts the learning culture and students' understanding of electrical concepts. Despite this, the teachers recognized the potential of classroom activities and experiments to enhance comprehension. However, they faced time constraints that limited their ability to conduct such activities. Teacher 6, who favored conducting experiments in his class, believed that hands-on experimentation significantly improved students' understanding of electrical topics.

4.1.3. Theme 3: teaching strategies

All teachers acknowledged using various static illustrations to teach this topic. Teacher 1 preferred drawing circuit arrangements on the whiteboard in a traditional manner, asking students to replicate the drawings. Teacher 3, on the other hand, utilized PowerPoint presentations to display static diagrams, while

teacher 2 opted to refer to textbook diagrams due to time constraints that limited her ability to provide additional teaching materials. Teacher 1 also emphasized the importance of memorizing complex scientific terms.

> "*The difficult terms in science need to be memorized; there is no other way for students to become familiar with them. As teachers, we play a crucial role in helping them memorize these terms*."

Occasionally, teachers incorporated videos to enhance students' understanding. All teachers agreed that experiments were valuable in allowing students to experience real-life applications of the concepts.

4.1.4. Theme 4: teaching higher-order thinking skills

All six teachers expressed their recommendations for improving the teaching of HOTS in electrical topics during the interviews. Under the sub-theme of active learning tasks, all teachers emphasized the need to encourage students to ask more questions in class, noting that questions were rarely posed during teaching and learning, except during experimental activities [7]. As teacher 5 remarked, "*teachers play a crucial role in engaging students during active learning tasks*." In the technology sub-theme, all six teachers agreed that incorporating videos, animations, and diagrams that mimic real structures could help students better understand the structure and processes of series and parallel circuits [22]. Teacher 2 stated, "*I believe using technology such as animations or videos can help students visualize the process*." This view was supported by teachers 4 and 6, who noted that visualization significantly aids students in grasping the concept of electrical circuits. The six teachers also stressed the importance of having a clear strategy for teaching HOTS, which is essential for students to comprehend fundamental scientific concepts and apply their knowledge across different topics. They agreed that varied instructional strategies are necessary to effectively teach students to understand and apply these concepts.

4.2. Discussion

The current study investigated Malaysian teachers' experiences in developing a teaching module to improve HOTS among students in primary schools. The present findings showed that these four elements were also necessary for creating a module in the classroom to enhance HOTS among students that in line with the finding of previous study [34]. The researchers used interviews to explore science teachers' perceptions of developing a module to enhance HOTS and overcome the obstacles they have experienced in their classrooms. Past research has shown that teachers must have a combination of subject matter, general pedagogical, and pedagogical content knowledge when teaching specific topics [15], [16], [35]. HOTS is crucial for effective learning and is the core purpose of scientific education [8], [36]. Electrical topics often involve abstract concepts such as electric current, voltage, and series circuits. By developing modules that convey these concepts in a clear and easy-to-understand manner, students can improve their HOTS in understanding complex science concepts. Furthermore, electricity also involves aspects of circuit design and construction. By providing opportunities for students to design, build, and test their circuits, teaching modules can encourage creativity and innovation in their approach to electrical problem-solving. The ever-changing and challenging world requires students to go beyond the building of their knowledge capacity. They need to develop their HOTS, such as critical system thinking, decision-making, and problem-solving [37]. There is no doubt that the development of HOTS among students is prominent; however, for that to occur, teachers must acquire and practice these skills.

5. CONCLUSION

This study provided useful insight into science teachers' experiences regarding the promotion of HOTS. This study indicated that the participants highly perceived implementing HOTS in 21st-century learning. However, the participants faced some challenges in implementing HOTS in science teaching. Malaysian schools have been using the HOTS module for more than five years. We are now uncertain about how the module was implemented in classrooms and whether it met its stated goals. The present study has given some insight into Malaysian schools' application of science modules and the use of HOTS by teachers. It has shown some discrepancy between what is occurring in classrooms and the real situation. The results of this study showed that students require a suitable module to improve their HOTS.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Siti Salina Mustakim				✓		✓	✓			✓	✓	✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
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Fo : **Fo**rmal analysis
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R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

No conflict of interest.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author, [HM], upon reasonable request. Access to the data may be subject to ethical considerations and the intended purpose of use.

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