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The Integration of Higher Order Thinking Skills in Science Classrooms: Malaysian Teachers' Perspectives and Practice

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Abstract

This study explores secondary school Malaysian teachers' conceptions of Bloom's Taxonomy of the cognitive domain and their integration of Higher Order Thinking Skills (HOTS) in science instruction and assessment. Employing a qualitative research design, the study involved semi-structured interviews with four science teachers from two secondary schools to investigate (1) teachers' understanding and perceptions of Bloom's Taxonomy, and (2) their strategies for incorporating HOTS in their instructional and assessment practices. The findings unveiled the teachers' optimistic views on Bloom's Taxonomy and its perceived positive impact on student learning. However, their integration of the taxonomy into instruction was limited, with the inclusion of Lower Order Thinking Skills (LOTS) and HOTS tasks and activities contingent on the academic abilities of the student groups. Notably, some teachers harbor a misconception that only high-ability students can engage in HOTS, leading to an emphasis on LOTS activities in classrooms with lower-ability students. Additionally, teachers were found to utilize different sets of pedagogical approaches and strategies when dealing with low-ability and high-ability groups of learners. The study concludes that there is a critical need for targeted professional development to correct misconceptions and enhance teacher capabilities in effectively integrating HOTS. Future research should examine the influence of teacher beliefs on instructional practices more comprehensively, incorporating classroom observations and document analysis to provide a more holistic understanding of how cognitive domain theories are integrated into practical teaching methodologies.

Keywords: Higher Order Thinking Skills, HOTS, Bloom's Taxonomy, Cognitive Domain, Science Teaching

Introduction

In today's global educational landscape, there is an increasingly pronounced emphasis on the integration of Higher Order Thinking Skills (HOTS) as a primary educational objective. This shift is spurred by the crucial awareness that the traditional rote memorization-based curricula no longer suffice in preparing students for the complex challenges of the 21st century (Chusni et al., 2022; Mayer, 2002; Ministry of Education Malaysia, 2013; Rosli et al., 2022). The decline in performance of many countries on international assessments such as Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMMS) highlights the urgency of cultivating critical thinking skills among students (Kadijevich et al., 2023; OECD, 2019; Yoki et al., 2018). To address this issue, educational systems across the world have adopted Bloom's Taxonomy as a foundational framework for curriculum development (Ministry of Education Malaysia, 2013; Yoki et al., 2018). This taxonomy, with its hierarchical structure of cognitive skills, serves as a guiding principle in crafting learning objectives that progressively nurture HOTS (Anderson & Krathwohl, 2001; Ching & da Silva, 2017; Momen et al., 2022). As a result, it has a significant impact on shaping teachers' professionalism, compelling educators to reevaluate and redesign their teaching methodologies to foster a generation of learners equipped with the critical thinking prowess needed to thrive in the evolving world (Mayer, 2002; Momen et al., 2022).

The adoption of school-based assessment (SBA) curricula reflects a strong commitment to fostering a comprehensive and skills-centred approach to education (Ministry of Education Malaysia, 2013, 2017; Rosli et al., 2022; Yoki et al., 2018). Singaporean teachers, for example, were encouraged to formulate assessment tasks that necessitate students' demonstration of both Lower Order Thinking Skills (LOTS) and HOTS–a framework intricately aligned with Bloom's cognitive domains (Leong, 2020; Tan, 2022). Similarly, Finland stresses the value of formative assessment methods and places a premium on nurturing students' proficiency in problem-solving and critical thinking, underscoring their unwavering commitment to HOTS (National Board of Education, 1999; OECD, 2010; Vainikainen & Harju-Luukkainen, 2020). New Zealand, with its pioneering curriculum, incorporates SBA designed to gauge students' acumen in critical thinking and the application of knowledge within real-world contexts (Education Review Office, 2018; Nusche et al., 2012). The adoption of SBA paradigms across these nations highlights the imperative of cultivating higher-order cognitive skills and the seamless integration of Bloom's Taxonomy into the educational milieu, acknowledging that assessing these skills is just as vital as teaching them (Ching & da Silva, 2017; Momen et al., 2022; OECD, 2019).

In Malaysia, the implementation of the Primary School Standard-based Curriculum and the Secondary School Standard-based Curriculum have called for a radical change in the way teachers approach their instruction and assessment practice (Md Ali et al., 2015). The Classroom-based Assessment (or PBD for Pentaksiran Bilik Darjah) assumes a critical role in this educational transformation (Curriculum Development Division, 2016; Ministry of Education Malaysia, 2017; Narinasamy & Nordin, 2018). This initiative exemplifies a robust commitment to the integration of informal assessment practices into the pedagogical and learning processes (Md Jaafar et al., 2024; Juhari & Zakaria, 2024; Zakaria et al., 2024), thereby steering teachers away from the conventional summative assessment-centric model towards a more formative-driven approach (Bahagian Pembangunan Kurikulum, 2016; Juhari & Zakaria, 2024; Md Ali et al., 2015). Central in guiding these assessment endeavours is the overarching reference to Bloom's Taxonomy, which serves as the cornerstone for framing both instructional and assessment activities (Ambotang & Gobalakrishnan, 2017; Md Ali et al., 2015; Ministry of Education Malaysia, 2013, 2017; Zakaria & Latif, 2021).

While numerous studies have scrutinized teachers' competency in employing Bloom's Taxonomy within the domain of assessment practices (Mohamed & Lebar, 2017; Sulaiman et al., 2015; Tan & Arshad, 2014), there exists a conspicuous gap in studies addressing teachers' ability to integrate this cognitive framework into their teaching processes. This void in the literature illuminates the novelty and importance of such an investigation. Studies measuring teachers' knowledge and competency in using Bloom's Taxonomy, particularly in constructing HOTS-related tasks, found that teachers recognized its importance but faced challenges in its integration (Cheda & Utha, 2021; Che Seman et al., 2017; Suhaili, 2014). This stemmed from teachers' awareness of the aspirations and goals of SBA and Classroom-based Assessment; however, they lacked the sufficient knowledge and know-how in the integration of Bloom's Taxonomy and HOTS-related tasks into their instructional activities (Che Seman et al., 2017; Wan Yusoff & Che Seman, 2018).

Consequently, this study was carried out to examine the conceptions and integration of Bloom’s Taxonomy encompassing cognitive, affective and psychomotor domains in science instruction and classroom assessments, in addition to identifying the constraints and challenges of such inclusion. This paper, however, focuses specifically on the discussion and findings related to the Bloom's Taxonomy of the cognitive domain, addressing two key research questions: 1) What were the teachers' conceptions of the Bloom's Taxonomy of the Cognitive Domain and HOTS? 2) How did teachers incorporate HOTS into their instructional practices?

A growing body of research emphasizes the crucial role played by the integration of HOTS-related tasks in elevating the depth and quality of student learning outcomes (Ching & da Silva, 2017; Chusni et al., 2022; Krathwohl, 2002; Momen et al., 2022; Pratiwi et al., 2017). Yet, delving into the complexity of how teachers incorporate these tasks within their instructional approaches can yield a more profound understanding of the extent to which teachers nurture critical thinking, analytical reasoning, and problem-solving skills in their students. These insights can, in turn, inform the development of specialized professional development programs and instructional strategies, thereby enhancing the overall effectiveness of educational practices and fostering more enriched and transformative learning experiences for students.

Literature Review

Taxonomy of Instructional Objectives: Cognitive Domain

The Taxonomy of Instructional Objectives (Cognitive Domain), initially delineated by Bloom and Krathwohl in 1956, systematically classifies cognitive processes into six distinct levels, each representing a progressive increase in complexity: knowledge, comprehension, application, analysis, synthesis, and evaluation (Krathwohl, 2002). In 2001, Anderson and Krathwohl introduced a revised iteration of the taxonomy, notable for its utilization of action verbs instead of nouns to delineate each level. The newer version posited that the six levels within the taxonomy which are remember, understand, apply, analyse, evaluate, and create to facilitate direct and discernible identification by teachers, a feature particularly advantageous in formulating instructional objectives (Anderson & Krathwohl, 2001; Krathwohl, 2002). Furthermore, this revised taxonomy emphasizes 'create' as the most intricate cognitive process, supplanting 'synthesis,' which occupied the fifth position in the original taxonomy. This transformation reflects a gradual evolution in the taxonomy's conceptualization, aligning it more effectively with contemporary educational contexts (Anderson & Krathwohl, 2001; Krathwohl, 2002). The effective alignment of instructional content with specific cognitive levels articulated within Bloom's Taxonomy not only heightens the relevance of learning but also fosters a deeper and more meaningful thinking process (Ching & da Silva, 2017; Momen et al., 2022).

Bloom and Krathwohl further classified the taxonomy's levels into two distinct categories: Lower-Order Thinking Skills (LOTS) and Higher-Order Thinking Skills (HOTS). LOTS encompass the three lower levels of the taxonomy, namely knowledge, comprehension, and application. They pertain to cognitive processes characterized by a foundational level of thinking, closely linked to pre-existing knowledge and subject matter content. Conversely, HOTS is concerned with logical, critical, creative, and metacognitive thinking, often applied to abstract and complex subject matter. HOTS encompasses the ability to analyse, evaluate, and create, which Bloom and Krathwohl (1956) regarded as the most intricate facets of information processing (Krathwohl, 2002). HOTS is distinctive in its nature as it encourages thinking beyond the given, enabling individuals with HOTS proficiency to scrutinize relationships, dissect problems, assess risks and values, and propose innovative solutions. These competencies are equally indispensable in diverse workplace settings (Anderson & Krathwohl, 2001).

Teachers' Integration of HOTS

Studies exploring teachers' perceptions of higher-order thinking skills (HOTS) and its integration in instructional practice has consistently revealed a reverse relationship. Although teachers have demonstrated positive attitudes toward HOTS and recognized its significance, their teaching methods have predominantly centred on lower-order thinking skills (LOTS) (Cheda & Utha, 2021; Che Seman et al., 2017; Suhaili, 2014; Wan Yusoff & Che Seman, 2018). In a study by Abdullah et al. (2017) on teachers' understanding of Bloom's Taxonomy, they observed that while teachers exhibited theoretical familiarity with the taxonomy, they encountered difficulties in distinguishing the differences in the characteristics and applications of LOTS and HOTS. Despite these gaps in knowledge, the authors reported that teachers remained committed to fostering creative thinking skills among their students.

Teachers were found to lack the necessary knowledge and skills to effectively integrate higher-order thinking skills (HOTS) into their pedagogical practices (Mohd Zhaffar et al., 2018). For instance, Wan Yusoff and Che Seman (2018) discovered that only half of the mathematics and science teachers in their study integrated HOTS into their questioning techniques. The majority of their inquiries were centred around factual and information recall, with a minimal emphasis on fostering critical thinking abilities. Moreover, the quality of science items crafted by teachers and perceived as HOTS-aligned was deemed to be subpar, lacking the essential characteristics necessary for effective HOTS items (Ishartono et al., 2021).

Studies examining the adoption of Bloom's Taxonomy, particularly in the cultivation of HOTS among students, have portrayed classrooms that predominantly manifested lower-order cognitive processes. Kassim and Zakaria (2015) reported that teachers tended to rely on a limited repertoire of strategies to foster HOTS, resulting in a prevalence of lower-order cognitive engagement among students. The teachers in Mahamod and Lim's (2011) study largely adhered to traditional instructional approaches. In such teacher-centered learning environments characterized by predominantly one-way communication, the facilitation of HOTS was notably challenging. Conversely, Azhari and Ismail (2013) and Cheda and Utha (2021) found that teachers possessed the requisite knowledge and skills to integrate HOTS into their lessons but persistently adhered to conventional teaching methods. These findings collectively highlighted the significance of a paradigm shift in instructional approaches to authentically nurture HOTS among students.

Teachers were also reported to hold misconceptions about HOTS (Che Seman et al., 2017; Lindahl, 2016; Samo, 2017). They regarded HOTS-related tasks and items as exclusively suitable for high ability students, whereas lower ability students were perceived as capable only of responding to or completing LOTS-related tasks and items. Consequently, there tends to be a tendency among teachers to marginalize lower-ability students and disproportionately focus on their high-ability counterparts during classroom activities that involved HOTS (Che Seman et al., 2017; Wan Yusoff & Che Seman, 2018). Lindahl's (2016) investigation highlighted a prevailing belief among English language teachers that HOTS are only pertinent for English language learners who have attained a certain level of proficiency, rendering them unsuitable for novice and beginner speakers. Similarly, Samo (2017), who explored the conceptions of 50 mathematics pre-service teachers regarding HOTS, unveiled that these pre-service teachers frequently associated LOTS with simpler problem-solving and remembering, while associating HOTS with the more intricate and challenging aspects of problem-solving skills. These misconceptions emphasized the need for comprehensive teacher training programs that can rectify such beliefs and promote a more inclusive approach to nurturing cognitive skills in students of varying abilities.

Research Questions

The study aimed to explore teachers' conceptions of Bloom's Taxonomy and the extent to which the taxonomies were integrated in science instruction. It was specifically guided by the following research questions:

1) What were the teachers' conceptions of the Bloom's Taxonomy of cognitive domain?
2) How did teachers integrate HOTS into their instruction and assessments?

Method

A qualitative inquiry with a case study design is employed as the research methodology for the study. Qualitative research seeks to explore and understand various aspects of human experiences, often associated with instructional practices (Brikci & Green, 2007; Creswell, 2013; Merriam, 2009). This approach is well-suited for investigating phenomena related to human or social issues Creswell (2013); with researchers engaging in a research process that involves developing research questions and procedures while collecting data in the natural settings of the participants. This approach requires a deep engagement with the data to generate meaningful interpretations (Astalin, 2013; Creswell, 2013). A case study approach was adopted to provide focused and detailed insights into individual cases, with a particular emphasis on the extraction of 'naturally occurring knowledge sources' (Stake, 1998, p. 97). Case study research is a common method used for exploring individual cases, groups, or phenomena (Creswell, 2013; Yin, 2014). The flexibility of this approach in accommodating a wide range of research designs, as noted by Hyett et al (2014), distinguishes it from other qualitative methodologies and makes it a valuable choice for this research endeavour.

Sampling

Four science teachers from two secondary schools participated in the study. Both schools located in an educational district in Selangor, one of the states in Malaysia. The schools were daily government schools running on two sessions, sharing similar characteristics. Both schools streamed their students according to ability levels during the learning of science and mathematics. Typical case sampling under the purposive sampling technique was utilized in the selection of schools and the participating teachers. Purposive sampling was defined as the selection made based on the researcher's judgment under which the sample fit the characteristics prescribed by the researcher (Palinkas et al., 2015). Many authors Benoot et

al (2016); Palinkas et al (2015); Patton (1990); Suri (2011) viewed purposive sampling technique as a meaningful technique for studies framed by qualitative design. Palys (2008) described typical case sampling as selection made based on common characteristics shared between the samples and the target population.
The research methodology employed in this study entailed the utilization of semi-structured interviews, a method selected for its adaptability, enabling thorough and in-depth exploration to obtain comprehensive information (Alshenqeeti, 2014). Data was analysed thematically. Several measures were implemented to ensure the validity and reliability of the interview process and the resultant data. The interview questions underwent a pilot phase involving a science teacher from a different school in determining the clarity, flow, and potential ambiguities in the questions. Additionally, the consistency and accuracy of interview transcriptions were rigorously examined during the transcription process, with uniform coding criteria to maintain data interpretation consistency. Furthermore, the practice of member checking was undertaken, involving the validation of transcription accuracy by sharing the transcribed texts with the research participants. These procedures collectively contributed to the robustness of the research methodology.

Participants

The interview participants comprised four female science teachers selected from two daily secondary schools situated within a single educational district. The criterion for participant selection encompassed the inclusion of one teacher with less than five years of service and another with 15 to 20 years of service from each school. This categorization facilitated the identification of potential variations in instructional practice. All teachers taught upper secondary students (form four and five students). For the purpose of this study, teachers with a shorter tenure are referred to as junior teachers, while those with 15 to 20 years of service are addressed as senior teachers throughout the subsequent sections of this article.

Findings

Teachers' Conceptions of Bloom's Taxonomy of Cognitive Domain

The first research question explores the science teachers' conceptions towards Bloom's Taxonomy of cognitive domain. The teachers demonstrated a positive outlook towards the taxonomy, highlighting its significance in fortifying and enhancing the teaching and learning process, as well as in improving the quality of their classroom assessments. They further acknowledged the taxonomy's positive influence on their professionalism. Notably, the emphasis on the cognitive domain taxonomy was more pronounced in the context of assessments, particularly in item development, as opposed to its integration within their instructional practices. The teachers perceived the cognitive domain taxonomy as an invaluable tool that provides a structured framework for creating test items, thereby enhancing the overall quality of assessments and refining their competency in item construction. Additionally, they highlighted the taxonomy's role in promoting students' cognitive abilities and shaping their analytical approach to solving scientific problems.

Provision of Framework and Structure in Item Construction Process

In comparison to their senior counterparts, the junior teachers were introduced to the teaching profession within an educational landscape already emphasizing the significance of integrating the Bloom's Taxonomy. Commencing their careers with a comprehensive grasp of the taxonomy's role, both in science assessments and instructional practices, these junior

teachers exhibited firm convictions regarding the critical nature of formulating assessment tasks and tools. Furthermore, their demonstrated beliefs encompassed the development of comprehensive lesson plans and the implementation of instructional strategies integrating a diverse range of both lower and higher order thinking skills-related tasks.
The senior teachers, however, were able to draw comparisons to their item development process prior to the current curriculum. Both teachers believed that the taxonomy provided structure and guidance to their item construction process, leading to the improvement of item and test quality. The senior teachers admitted that before the reference of Bloom's Taxonomy, they had no guidelines for item development. They relied on their content knowledge and teaching experience to determine item difficulty and quality.
The senior teacher from school A indicated, "Of course the process of developing questions was easier [in comparison to using the taxonomy] and when we developed questions, we simply categorized them as easy and hard questions." Responding to a question on how she distinguished easy and difficult items, the teacher stated, "There was no general guidelines, really. I would decide based on the complexity of the content. So easy content would be generated into easy questions, and more difficult content would make into difficult questions." She added, "When we started using Bloom's, I eventually realized that maybe what we were doing before was not as effective. The taxonomy makes me understand that there are wider range of difficulties and not simply hard or easy."
Echoing similar experience, the senior teacher from School B revealed, "I was basing my item development process on my knowledge of science content. Of course, we have an item bank system where we deposited questions into the bank from time to time. And some questions in the test were based on items which we found in the reading materials or other resources. But when I prepared my test, the decision whether a question was easy or difficult would be based on my content knowledge."

Improvement of Teacher Knowledge and Skills
All four teachers in the study unanimously agreed that the use of the taxonomy improved their knowledge and skills in item construction. The junior teachers held the view that the adoption of the taxonomy specifically enhanced their item development skills, particularly in the construction of test and examination questions. One of the junior teachers believed that the gradual exposure to writing items using the taxonomy had improved her analytical skills in evaluating the quality of the items that she developed. The responses provided by the senior teachers demonstrated an increased sense of empathy for students, particularly the ways in which the assessments implemented impacted students and their cognitive processes. One of the senior teachers commented, "I used to consider questions as a means of measuring content. But now, I also consider how my questions affect the way my students answer." Another senior teacher remarked, "I am now more sensitive to how my students would answer the questions, particularly in the incorporation of both LOTS and HOTS. So, yes... even when I plan my test, how students approach my questions is also one of my considerations."

Enhancement of Students' Cognition
In addition, the science teachers concurred that the utilization of questions addressing various cognitive levels within Bloom's Taxonomy had a positive impact on their students' critical thinking abilities. They observed that the diversified questioning techniques encouraged students to approach content from multiple perspectives, resulting in more

insightful and comprehensive responses. One of the senior teachers noted that the modifications in her questioning style prompted a corresponding shift in her students' cognitive processing and the articulation of their answers. On the other hand, a junior teacher highlighted her students' struggles in effectively responding to HOTS questions, citing limited language proficiency as a primary obstacle. However, she noticed an improvement in their critical thinking during classroom discussions and activities involving HOTS questions. All teachers in the study emphasized the necessity of providing students with sufficient time and exposure to Bloom's Taxonomy in their learning materials to cultivate the skills required for adeptly addressing questions and tasks.

Advancement of Teachers' Professionalism

The teachers associated the adoption of Bloom's Taxonomies to the enhancement of their professionalism. They emphasized the utility of the taxonomy in improving their reporting process. The junior teacher stated, "Look. I think in a way it boosts our profession as a teacher. Not only that we are able to come up with better questions, we have a framework which helps us to do this. It looks good to parents." In addition, the senior teacher attributed the use of the taxonomy to the provision of more comprehensive feedback for parents and students. Previously, her feedback primarily focused on grades and steps for improvement. With the incorporation of the taxonomy, the teacher included comments on students' cognitive tasks in her reports, ultimately enhancing her professional approach.

Misconceptions towards HOTS

A junior teacher and a senior teacher appeared to hold the misconception that students with lower academic abilities were not equipped to handle HOTS tasks and items. The teachers perceived that only students with higher academic capabilities were capable of effectively engaging with HOTS-related content. The junior teacher highlighted the challenges her low-ability students faced in responding to HOTS questions, suggesting that their struggles were indicative of their limited capacity to effectively navigate such complex tasks. However, the remaining junior teacher disagreed with this sentiment. She believed that all students were equipped with the capacity to solve both lower and more complex problems and complete complex scientific tasks. She argued that low-ability students struggled with HOTS-related tasks and items not because they lacked the mental capacity to exercise thinking skills at particular levels, but due to their limited mastery of more advanced scientific concepts. She proposed that the utilization of HOTS tasks and items representing a range of simple to more complex scientific concepts would enable all students to answer them effectively, regardless of their levels of ability.

Teachers' Integration of Bloom's Taxonomies in Science Instruction and Assessments

The second research question examined the teachers' incorporation of Bloom's Taxonomy in their science instruction and classroom assessments. The findings revealed that teachers' integration of the taxonomy in their instruction was minimal and the incorporation of LOTS and HOTS-related tasks and activities was dependent on the ability groups of the students that they were teaching. This was prevalent in science classrooms of three teachers in the study. In instances where HOTS were incorporated into lessons for low-ability student groups, the teachers provided additional guidance to facilitate comprehension. The integration of LOTS and HOTS-components in teachers' classroom assessments was limited to item development for tests and examinations. The proportion of LOTS and HOTS-items in the test instruments was found to be dependent on the students' level of ability.

The Proportion of LOTS-HOTS-integrated Tasks in Science Lessons

The findings revealed that the teachers' narratives of HOTS-oriented tasks and activities in science instruction were often associated with the learning of students with higher academic abilities. The inclusion of HOTS-related tasks in the science classrooms was commonly facilitated through problem-based and inquiry-based learning approaches.

Although three of the teachers admitted to the use of both LOTS and HOTS in their instructional practices, the descriptions of how HOTS were integrated revealed that the integration of HOTS was predominantly confined to assessments, specifically tests and examinations. The incorporation of HOTS-related questions within regular lessons was minimal, often restricted to activities targeting specific learning outcomes associated with HOTS' cognitive processes. Conversely, when addressing learning outcomes aligned with LOTS, the teachers primarily employed classroom activities and written exercises focusing on LOTS-specific tasks. Nevertheless, all teachers confirmed their periodic use of both LOTS and HOTS items during question-and-answer sessions.

All teachers, with the exception of one junior teacher, admitted to using higher proportion of HOTS-related items and tasks in lessons and assessments involving high ability group of learners. However, considerations for the integration of HOTS in the lessons were predominantly guided by the learning outcomes measured for particular lessons. Teachers would work on integrating HOTS-related items and tasks when the lessons representing learning outcomes at the higher cognitive process of the Bloom's Taxonomy. Their lessons would predominantly focus on tasks of lower cognition when the learning outcomes were represented by LOTS even when the groups they were teaching were primarily high ability students.

HOTS-oriented Tasks in Lessons Involving Students of Lower Academic Ability

The findings further highlighted that when HOTS' tasks were introduced in lessons tailored for groups with lower academic abilities, the teachers supplemented these tasks with additional guidance. These were in the forms of lengthy descriptions and explanations, the provision of multiple examples, and the demonstration of step-by-step procedures for resolving HOTS-oriented tasks. Furthermore, the teachers engaged in teaching sessions characterized by repetitive instruction and interactive question-and-answer segments to reinforce the students' understanding and mastery of the subject matter. They believed that such guidance was imperative in facilitating a better understanding of the questions and in assisting the students to respond accurately. Both junior and senior educators emphasized the significance of time, exposure, and teacher guidance in nurturing the ability of students with lower academic proficiency to effectively engage with HOTS items. One of the junior teachers stressed the importance of patience in managing HOTS-focused tasks in classrooms with students of lower abilities, acknowledging that an extended period would be required to provide adequate support for the students.

The Influence of Teachers' Misconceptions towards HOTS on Teaching Practice

A junior teacher and a senior teacher appeared to hold the misconception that students with lower academic abilities were not equipped to handle HOTS tasks and items. The two teachers perceived that only students with higher academic capabilities were capable of effectively engaging with HOTS-related content. The junior teacher highlighted the challenges her low-ability students faced in responding to HOTS questions, suggesting that their struggles were indicative of their limited capacity to effectively navigate such complex tasks. She emphasized that presenting HOTS questions to these students without adequate support risked demoralizing their learning experience. In her experience, the integration of HOTS tasks in science lessons for low-ability learners often yielded discussions lacking depth and meaningful engagement. When asked about her strategies for facilitating HOTS-focused learning outcomes with low-ability students, the teacher emphasized the importance of content mastery. She stressed on the use of various activities such as games, discussions, and quick presentations to reinforce learning and maintain student engagement. The teacher highlighted her focus on content mastery rather than emphasizing HOTS in her lessons with low-ability groups, while highlighting the prevalence of HOTS-related tasks in her lessons with high-ability classes.

Elaborating on her perspective, the senior teacher commented, "Sometimes I might need to employ Bloom's Taxonomy in the psychomotor domain when instructing lower-achieving classes. The high-achieving classes face no issues with the application of Bloom's Taxonomy in the cognitive domain." In response to inquiries regarding whether the utilization of different domain taxonomies aligned with the same instructional objectives, she affirmed, "Indeed, it aligns with the same learning outcome, as most often the lower-achieving classes do not progress with the cognitive domain taxonomy." Further investigation into her instructional approach revealed a focus on practical skill-related tasks such as demonstrations, presentations, and discussions to accommodate lessons for students with lower academic capabilities. In contrast, when guiding groups primarily comprised of high-achieving students, she integrated the curriculum with HOTS-oriented tasks and activities, including problem-based learning and inquiry-based learning that stimulated discussions at the HOTS level.

Discussion

The study has raised pertinent issues concerning the significance of teacher knowledge in ensuring that positive conceptions towards HOTS are translated into teaching practice. Despite the favourable outlook towards the taxonomy, the findings unveiled that teachers predominantly incorporated lower cognitive levels in their instructional practices, with the application of HOTS largely confined to the construction of assessment items.

These findings aligned with the findings of other studies which reported a notable disparity between the teachers' conceptions of the Bloom's Taxonomy and the inclusion of the taxonomy in their instructional practice (Abdullah et al., 2017; Cheda & Utha, 2021; Che Seman et al., 2017; Suhaili, 2014; Wan Yusoff & Che Seman, 2018). As a result, lessons remained at lower-level cognition despite the curriculum requirement that emphasizes on nurturing critical thinking skills. It can be posited that teacher knowledge plays a crucial role in bridging positive conceptions and translating teachers' favourable perspectives into actual classroom practices. Various studies have highlighted the significance of teacher knowledge in the integration of Bloom's Taxonomy in teaching practice (Abdullah et al., 2017; Abdullah & Darusalam, 2018; Anggraeni & Sole, 2020; Mat Nor & Kamarudin, 2017; Mohd Zhaffar et al., 2021; Nor et al., 2015). For instance, Abdullah and his colleagues (2017) reported the relationship between mathematics teachers' level of HOTS' knowledge and practice with the aspects of curriculum, pedagogy and assessment. Zhaffar et al (2021) identified that the lack of Arabic language proficiency, pedagogical knowledge, content mastery, and understanding of HOTS' application among religious teachers resulted in religious lessons devoid of dynamic reasoning ability

The study has brought to light important issue concerning science teachers' misconceptions towards HOTS and the detrimental effects of these misconceptions on their instructional practice and student learning. The teachers espoused the belief that students with lower academic abilities lacked the capacity to successfully complete HOTS-related tasks, contrasting with the perceived ability of high-achieving students to navigate such tasks adeptly. While this misconception was particularly evident among two teachers in the study, the findings indicated that a prevalence of low-level cognition was a common characteristic of three teachers in the study. This misconception seemingly exerted a negative influence on the teachers' instructional practices in three ways. Firstly, it led to a disparity in the cultivation of HOTS among students of lower and higher academic abilities. Lessons tailored for students with lower academic abilities predominantly centred on lower-order cognition, while the high-ability groups received more exposure to HOTS tasks and activities. Prolonged engagement with tasks and activities at a lower cognitive level could potentially limit the development of higher-order cognition among students with lower academic abilities. Additionally, these students would continuously be provided with unchallenging tasks and questions due to the perceived lack of capacity to address HOTS-oriented tasks and problems. Secondly, the misconception resulted in an emphasis on psychomotor-focused activities for students with lower academic abilities rather than on cognitive-oriented tasks. The findings revealed that this teacher did not reference any taxonomies in the psychomotor domain, assuming that her emphasis on psychomotor components aligned with the corresponding taxonomy. This misinterpretation not only undermined the teacher's professionalism but could potentially have adverse effects on student learning over time. Each domain of learning taxonomy delineates specific learning objectives for distinct areas of learning: cognitive taxonomies describe mental capacities and thinking abilities; affective taxonomies address the continual emotional development of mindsets; and psychomotor taxonomies involve the development of physical skills (Anderson & Krathwohl, 2001; Krathwohl, 2002; Momen et al., 2022). Prioritizing the psychomotor taxonomy over the cognitive taxonomy fosters learning objectives incongruent with cognitive-focused learning outcomes, as the emphasis of the psychomotor taxonomy lies in skill development (Momen et al., 2022). Prolonged exposure to such teaching and learning environments could impede students' cognitive growth and hinder the cultivation of their mental capabilities. Significantly, this approach could hinder the accomplishment of the intended learning outcomes and the curriculum's aspirations.

Lastly, the identified misconception has led to a dearth of diversity in the pedagogical approaches and strategies employed by the teachers, resulting in the adoption of similar instructional methods during the incorporation of HOTS for both high-ability and low-ability student groups. Lessons catering to high-achieving students were characterized by problem-based and inquiry-based learning methodologies in which, according to the teachers, fostering intricate problem-solving abilities and facilitating in-depth discussions among the students. In contrast, HOTS-focused learning outcomes for students with lower academic abilities predominantly involved practical skill-related tasks, such as demonstrations, presentations, and group discussions, designed to accommodate their learning needs. The lack of diversity in pedagogical strategies and the resulting stagnant learning environment during the integration of HOTS have also been documented in findings of other studies. For instance, Che Seman et al (2017); Wan Yusoff and Che Seman (2018) reported that primary school teachers in their respective studies exhibited a limited range of questioning techniques. These teachers were noted to adhere to a fixed questioning style, often employing only LOTS questions, despite possessing the necessary understanding to formulate questions at the HOTS level. Similar observations were made in the study conducted by Kassim and Zakaria (2015), who highlighted the lack of diversity in instructional strategies among primary school mathematics teachers, demonstrating a tendency to rely on the same questioning style and mind map formats in their integration of HOTS.

Implications

Teacher knowledge is crucial in the effective integration of HOTS. The findings of this study accentuated the imperative need for comprehensive and continuous professional development programs geared towards enriching teacher knowledge and fostering adept integration of HOTS. These initiatives should explicitly offer practical demonstrations, exemplars of best practices, and strategies for successful integration, thus enabling teachers to acquire precise and comprehensive knowledge. Furthermore, these programs should be designed to identify and address any prevalent misconceptions that teachers may hold with regard to the implementation of HOTS.

Additionally, teachers, themselves, should assume the role of the agents of change and advocates of the lifelong learning philosophy. As reflective practitioners, teachers should engage in self and peer evaluations, and familiarize themselves with pertinent and effective pedagogical approaches and strategies related to HOTS to advance the teaching and learning of science.

The successful integration of HOTS requires substantial support from school administration and policymakers, alongside the provision of an enabling environment that promotes and sustains transformative practices among teachers. Allocating adequate time, resources, and materials for teachers to proficiently plan and execute HOTS-based activities and assessments remains important. Establishing an ecosystem that fosters and encourages the assimilation of HOTS within the curriculum is essential for enduring success. Implementing a mentor-mentee system, either within individual schools or across different schools, can serve as a valuable platform for teachers to seek guidance, clarification, and expert advice on HOTS integration. Such a supportive structure can significantly bolster teachers' confidence and competence in effectively implementing HOTS-oriented tasks and activities.

Conclusion, Limitations and Future Research

The current study explores the perceptions and integration of HOTS within the science classrooms of four teachers from two demographically similar schools. Employing a case study research design, data was collected through semi-structured interviews. The teachers exhibited favourable conceptions towards the Bloom's Taxonomy and HOTS, recognizing their inherent value in enhancing pedagogical skills, fostering analytical capabilities, providing structure to the item construction process, improving student cognitive abilities, and augmenting professional practice. Despite these positive perspectives, a prevalent misconception was identified among the majority of the teachers, suggesting that students with lower academic abilities lacked the capacity to proficiently engage with HOTS-oriented tasks and activities, in contrast to their higher-achieving counterparts. This misconception influenced the instructional focus, resulting in a dominance of LOTS in science education for students with lower academic abilities, while HOTS-related tasks were predominantly integrated into lessons involving high-achieving students. Furthermore, an adherence to similar instructional approaches and strategies were observed in HOTS-oriented classrooms, with practical skills and demonstrations emphasized for lower-ability groups, and inquiry and problem-based learning approaches employed for higher-ability groups.

A significant limitation of this study is the utilization of a singular method for data collection. While efforts were made to ensure the study's reliability, incorporating multiple data collection methodologies would have facilitated triangulation, thus bolstering the credibility of the results. Furthermore, the qualitative nature of this research limited the generalization of the findings to a broader population. Nevertheless, the inclusion of a larger cohort of science educators as study participants would have led to more robust and comprehensive findings. Moreover, although the study delved into teachers' conceptions and integration of HOTS within science instruction, the incorporation of teacher beliefs and knowledge into the research framework would have yielded deeper and more insightful findings.

Several recommendations for future research endeavours emerge in light of the presented findings. Firstly, there is a critical need for studies that delve into the influence of teacher beliefs on instructional practices. As evidenced in previous studies focusing on HOTS integration, misconceptions often originated from entrenched teacher beliefs. Examining these beliefs and their impacts on pedagogical decision-making would provide valuable insights for designing effective intervention strategies aimed at rectifying misconceptions and enhancing HOTS integration.

Secondly, future studies should consider incorporating a more comprehensive research design that encompasses teaching observations and document analysis, in addition to semi-structured interviews. Integrating these varied methodologies would not only contribute to a more holistic understanding of the teachers' instructional practices but would also facilitate triangulation, thereby enhancing the credibility and validity of the research findings. This multifaceted approach would provide an in-depth perspective on the complexities of HOTS integration within the classroom context. Moreover, the adoption of longitudinal or quasi-experimental designs in future research endeavours would enable a more robust exploration of the causal relationships and long-term impacts of HOTS integration, contributing significantly to the existing body of knowledge in this field.

Thirdly, in the context of Malaysia, it would be beneficial for future research to investigate the effectiveness of different types and formats of professional development (PD) programs in supporting teachers' understanding and implementation of HOTS. Exploring diverse PD models tailored to the specific needs of Malaysian educators could offer valuable insights into the most effective approaches for promoting successful HOTS integration. Moreover, an in-depth exploration of the contextual factors that impact the adoption and sustainability of various PD initiatives would contribute to the development of targeted and contextually relevant professional development programs.

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