Problem-solving practices, beliefs, and digital mindtool use among Malaysian secondary school science teachers

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Abstract

Problem-solving is a critical competency in an increasingly technologically-mediated world. However, Malaysian students' weak performance in science-related problem-solving could be related to the instruction they received. Hence, this study investigates the instructional strategies, digital tool use, and problem-solving beliefs of secondary school science teachers in 2023 using a cross-sectional survey involving 419 secondary school science teachers. The learning skills questionnaire, grounded in modes of thinking framework, was employed. Descriptive analyses were employed to examine patterns of digital mindtool use, problem-solving strategies, and teacher beliefs. Results indicate that teachers reported frequent use of digital tools and high engagement with analogizing, modelling, causal reasoning, and argumentation strategies. However, beliefs about problem-solving reflected persistent misconceptions with an overemphasis on memorization. The findings highlight a misalignment between instructional practices and underlying beliefs, underscoring the need for professional development that integrates cognitive theory with digital pedagogy.

Keywords: keyword, keyword, keyword, keyword

INTRODUCTION

The ongoing industrial transformation is defined by advanced automation and smart computational systems, and nations such as Malaysia require sustained innovation to support economic development (DeWitt & Sukhoverkhov, 2023). While the technologies associated with Industry 4.0 emphasize enhanced efficiency and intelligent machine design, a human-centered orientation remains essential to ensure attention to people and long-term sustainability (Barata & Kayser, 2023). Consequently, the transition towards Industry 5.0 necessitates fostering human capacities to interact,

collaborate and solve problems with robots and intelligent systems (Adel, 2022). This underscores the urgent need for educators who can cultivate higher-order cognitive skills related to problem-solving, ensuring societies remain competitive in this evolving technological landscape (DeWitt & Sukhoverkhov, 2023; Saido et al., 2018).

Malaysia had focused on developing thinking skills for the future of work since the implementation of the smart schools in 1996 (DeWitt & Alias, 2023). However, despite this focus on cognitive skills, Malaysia had low scores in science for program for international student assessment (PISA) since 2015 (Azahar & Cheng, 2024).

Contribution to the literature
- There is a potential of using digital applications as mindtools to develop problem-solving skills as teachers are already using a variety of tools and applications. Teachers perceive that they apply the modes of thinking which are analogizing, modelling, reasoning causally, and arguing in their instructional strategies for science.
- Although teachers perceived that they were applying the principles of learning for teaching problem-solving, this did not seem to be aligned to their beliefs on problem-solving. This is because teachers believed that problem-solving was more for mathematics, that problem-solving did not involve thinking, and that memorizing facts and concepts seem to be important for learning.
- This may indicate that science teachers believed that a traditional approach is useful for teaching science and that solving problems was less important in science.

Secondary school students seem to lack higher level cognitive skills as they performed poorly when making inferences, interpreting data and distinguishing between inference and reasoning (Disa, 2022). Further, students who completed their secondary education seem to lack the cognitive reasoning ability for science and technology (Mohd Tajudin et al., 2019). In general, students seemed to be performing poorly in problem-solving and scientific reasoning for science (Rahmawati et al., 2022).

Teaching strategies which focus on traditional approaches for science seem to be ineffective for developing higher-order thinking abilities (Dewi et al., 2023). However, there are strategies to foster the development of higher-order thinking skills (Makransky & Petersen, 2021). Teacher professional development that strengthens instructional practice can contribute to improved student reasoning and other higher-order learning outcomes (Makransky & Petersen, 2021). Further, students who are taught to critically analyze scientific facts, improve in their higher cognitive ability and are able to solve science problems (Majeed et al., 2021).

Several studies suggest that educators often possess an incomplete understanding of critical thinking, largely due to the absence of a well-defined conceptual framework (Changwong et al., 2018; Gul & Akcay, 2020). Moreover, teachers frequently report challenges in promoting critical thinking and higher-order thinking skills within their instructional practices (Chalkiadaki, 2018). Problem-solving, the highest level of cognitive thinking, needs to be investigated to determine whether teachers were applying problem-solving teaching strategies. The principles of learning, based on the four modes of thinking: analogizing, modelling, reasoning causally, and arguing, is used to investigate the strategies for teaching problem-solving (Jonassen, 2013). Digital tools and applications have the potential to promote collaboration, interaction, and personal reflection among students (Pinto & Leite, 2020). In addition, as cognitive mindtools, these digital tools could foster higher order thinking and develop problem-solving skills (DeWitt & Alias, 2024; Jonassen, 2013).

Hence, it is important to determine the digital tools and applications that science teachers in Malaysia used as cognitive mindtools. Such tools could be used to encourage students to create their own knowledge and design solutions to problems and needs to be investigated (DeWitt & Alias, 2023).

However, teachers' beliefs are important for change (Gregoire, 2003). Teachers' beliefs influence their pedagogy as teachers' thinking processes have shown to affect their teaching practices (Watson, 2015). Teachers' beliefs on the concept of argumentation had impacted the extent that argumentation was integrated in the classroom (McNeil et al., 2016). Beliefs shape instructional practices, making them a critical component for understanding how teaching unfolds (Xenofontos & Andrews, 2012). Despite the recognized significance of teachers' beliefs, there is a noticeable gap in the literature concerning their beliefs about teaching problem-solving. Accordingly, the present study examines teachers' beliefs related to problem-solving instruction.

Despite increased emphasis on problem-solving and digital technology integration in science education, there is limited empirical evidence on how these are enacted in Malaysian secondary school classrooms. Existing studies often examine instructional strategies, technology use, or teacher beliefs separately, resulting in an incomplete understanding of problem-solving instruction. Consequently, the alignment between teachers' reported practices, digital tool use, and underlying beliefs remains unclear. This study addresses this gap by describing the digital tools used by science teachers, the problem-solving strategies they employ, and their beliefs about problem-solving instruction, by aiming to achieve the following objectives:

(1) to determine the technology devices and applications used by secondary school science teachers,

(2) to investigate the problem-solving teaching strategies used among secondary school science teachers, and

(3) to investigate the problem-solving beliefs among secondary school science teachers.

The findings of the study would be significant to educators and teacher trainers to determine what technology applications were used and how these applications are currently being employed. In addition, the current teaching strategies and beliefs about problem-solving among teachers could be identified to determine if there was a need to improve the existing teacher training programs so as to develop problem-solving capabilities among students. This is essential as changes in the curriculum, assessment and professional development may be required (Wilson & Narasuman, 2020).

The Issues Related to Problem-Solving

Problem-solving does not seem to be emphasized. Although models of instruction for critical thinking have been used in schools, they seemed to be insufficient (Ministry of Education Malaysia, 2013). In PISA for science, scores have been decreasing since 2015 (Azahar & Cheng, 2024). In 2018, only 63% attained level 2 or higher (Organisation for Economic Co-operation and Development [OECD] average was 78%) (OECD, 2019) while in 2022 it decreased to 52% (OECD average was 76%) (OECD, 2023). This indicates that at minimum, students had the ability to recognize correct explanations for scientific phenomena and can identify whether conclusions are valid (OECD, 2023). Further, in 2018 and 2022, only 1% of Malaysian students were top performers in science achieving the higher skill levels of 5 and 6 (OECD average of 7% for both 2018 and 2022) (OECD, 2019; OECD 2023). Hence, there is a need to emphasize the development of thinking skills for problem-solving and scientific reasoning (Rahmawati et al., 2022).

However, Tee et al. (2018) asserted that conventional teaching techniques have been employed in Malaysia and these have been ineffective in cultivating students' critical thinking capacity. Although there have been efforts to develop higher order thinking in science education, these are few and scattered (Saido et al., 2018). Hence, suitable pedagogies and activities to foster students' higher order thinking and creativity need to be emphasized (DeWitt & Alias, 2023). This is more important in science education as the scientific process and reasoning should be prioritized and not memorizing information (Disa, 2022).

Scientific thinking should involve inquiry-based learning, developing hypotheses, designing experiments, and evaluating the outcomes from the testing (Saido et al., 2018). Digital tools as cognitive mindtools, also have the potential to improve scientific thinking and problem-solving (Chinn & Clark, 2013; Mason, 2014). This is because collaborative learning with digital tools can enhance the process of knowledge building and problem-solving (Mayweg-Paus et al., 2021). Further, digital applications can support the construction of knowledge and scaffold the reasoning process by organizing content for analytical reasoning and thus reducing the cognitive load (Jonassen, 1996).

Although cognitive mindtools can be applied for enhancing the modes of thinking during the problem-solving process, teachers may not be using digital tools. Teacher training programs do not seem to emphasize the importance and use of digital technologies (Lai Wah & Hashim, 2021). As a result, teachers may be unaware that digital tools can be used for developing thinking skills or may not be using these tools adequately.

The Modes of Thinking and Cognitive Mindtools

The principles of learning can be used for teaching problem-solving based on the processes involved in thinking (Jonassen, 2013). Authentic problems ensure the development of meaningful, experiential knowledge (Jonassen, 2013). In the process of solving problems, questions are asked, opinions are supported and defended through argumentation and reasoning (Toledo & Dubas, 2016). These processes are described through the four modes of thinking, which are analogizing, modelling, reasoning causally, and arguing (Jonassen, 2013). Digital tools can be used to enhance the thinking processes and suggestions are made.

Analogies

Analogies are made when the information from a past experience is transferred to a new phenomenon in the process of understanding it (Henriksen et al., 2014a). This process of analogical reasoning occurs when comparisons are made with existing schemas and more robust schemas are needed to address the new problem (Dick et al., 2014; Jonassen, 2013). Patterns are identified and structured from existing data and connections are made to find similarities and differences, and abstract the main ideas (Henriksen et al., 2014a, 2014b). For patterning, texts and visuals may assist learners in making meaningful connections. Tables or even mapping concepts using Smart Art on a word document, or a graphic tool such as Canva, may assist learners in finding meaningful (DeWitt & Alias, 2024). This is because visualization using technology tools contribute to a better understanding of concepts and aids in making connections (Doymus et al., 2010). Thus, the next process in abstraction can be facilitated as new alternatives and approaches are sought in productive problem-solving (Henriksen et al., 2014a).

Modelling

Mental models show relationships between different elements and are built when there is a challenging problem (Spector, 2010). Modelling is an attempt to build and test these representations in the human mind (Kim, 2012). It reduces the cognitive demand as existing knowledge is represented and made accessible and identifying patterns and making predictions becomes

easier (Bogard et al., 2013). Hence, cognitive mindtools enables learners to visualize their mental models in charts, images, hypermedia, data or even video and animated clips (DeWitt & Alias, 2024). Mental models may change during instruction (Dick et al., 2014; Kim, 2012). When challenged, the learner will have a deeper understanding of his model, and as changes are made to the model, this enables the processes of making predictions, inferences and experimentation to occur (DeWitt et al., 2014).

Causal reasoning

Concepts derived from logical reasoning can be used to make predictions, implications and inferences in causal reasoning (DeWitt & Alias, 2024). Based on a set of conditions, a hypothesis can be developed, which can then be tested (DeWitt & Alias, 2024). Hence, from a problem, a representation of the problem and possible solutions can be developed before an evaluation of the solution (Bulu & Pedersen, 2010). Representation of the problems can be done using simulations, visual tools or even videos (DeWitt & Alias, 2024). Students require metacognitive and regulation skills in order to make these predictions for causal reasoning (Bulu & Pedersen, 2010). However, generative artificial intelligence tools which makes use of large language models could also assist in making predictions.

Argumentation

Argumentation is important for scientific thinking as arguing and debating on scientific and societal issues enables scientific knowledge to be articulated and refined (Jonassen & Kim, 2010). Alternative theories are planned with counterarguments and rebuttals in argumentation (DeWitt & Alias, 2024). Skills for argumentation include the ability to generate causal theories to support claims, to offer evidence to support theories to make the arguments coherent (Jonassen & Kim, 2010). Cognitive mindtools such as a wiki, slide or video sharing platform enables sharing of information, the first step in argumentation (DeWitt & Alias, 2024). Next, for the process of argumentation, discussions on forums or interactive platforms could stimulate arguments to enable learners to be actively constructing their defense (Jonassen & Kim, 2010). The ability to generate alternative theories and to envision conditions that would undermine the theories or counterarguments and prepare for rebuttal to justify solutions and actions are needed (Jonassen & Kim, 2010).

Digital Technologies as Cognitive Mediators in Problem-Centered Learning

From a cognitive perspective, digital mindtools support higher-order thinking by enabling learners to engage in abstraction and pattern recognition through external representations. Such processes allow learners to move beyond surface features to identify underlying structures, relationships, and conceptual regularities. These forms of abstracting and patterning have been described as trans-disciplinary habits of mind that are central to complex problem-solving and knowledge construction (Henriksen et al., 2014a, 2014b). When supported by visualization, modelling, and representational digital tools, these habits of mind can be meaningfully integrated into problem-centered learning environments (Ainsworth, 2006; Jonassen, 1996).

Analogical thinking is supported through visualization and pattern-mapping tools that assist learners in identifying structural similarities across contexts (Ainsworth, 2006; Henriksen et al., 2014b). Modelling is enabled through simulations and representational software that allow learners to construct, test, and revise mental models in problem-centered contexts (Kim, 2012; Spector, 2010). Causal reasoning is facilitated by digital tools that allow manipulation of variables, prediction testing, and exploration of cause-effect relationships, thereby reducing cognitive load and supporting hypothesis testing (Bulu & Pedersen, 2010; Sweller et al., 2011). Argumentation is strengthened through collaborative platforms that support evidence construction, counter-argument generation, and rebuttal in socially shared reasoning environments (Chinn & Clark, 2013; Jonassen & Kim, 2010).

This framing positions digital technologies not as peripheral instructional supplements or delivery mechanisms, but as integral components of problem-centered cognition that actively mediate, structure, and augment higher-order thinking processes. When employed as cognitive mindtools, digital technologies shape how problems are represented, how information is organized and manipulated, and how learners engage in reasoning, reflection, and decision-making (Hutchins, 1995; Jonassen, 1996). Rather than simply supporting instruction, these tools become part of the cognitive system itself, enabling learners to externalize complex relationships, test hypotheses, and iteratively refine their understanding in ways that would be difficult to achieve through internal mental processes alone (Spector, 2010; Zhang & Patel, 2006). In problem-centered learning environments, such mediation allows higher-order thinking processes—such as abstraction, causal inference, and argumentation—to be distributed across learners and technological artefacts, thereby extending cognitive capacity and supporting sustained engagement with complex scientific problems (Jonassen & Kim, 2010; Sweller et al., 2011).

MATERIALS AND METHODS

Despite the theoretical potential of Jonassen's (1996) four modes of thinking and the widespread availability of digital technologies in schools, empirical evidence

remains limited regarding how secondary science teachers operationalize these modes in classroom practice. In the Malaysian context, it is particularly unclear whether teachers' reported use of digital tools aligns with cognitively productive problem-solving strategies, and how their beliefs about problem-solving shape these practices. Addressing this gap, the present study examines the relationships between teachers' problem-solving strategies, digital mindtool use, and beliefs among Malaysian secondary school science teachers.

Study Design

This study adopted a cross-sectional exploratory survey research design, which is appropriate for examining patterns among variables within a naturally occurring educational context without manipulating instructional conditions (Creswell & Creswell, 2018; Fraenkel et al., 2019). Such designs are commonly employed in educational research to explore instructional practices, beliefs, and technology use based on self-reported survey data (Bryman, 2016).

The research explored the following:

(a) problem-solving instructional strategies grounded in Jonassen's (1996) four modes of thinking,

(b) digital tool use conceptualized as cognitive mindtools that mediate and support higher-order cognition, and

(c) teachers' beliefs about problem-solving.

The purpose of the study was exploratory rather than causal (Cohen et al., 2018). This design is particularly suitable for investigating belief-practice alignment and technology-mediated pedagogy in large-scale teacher samples, where experimental control is neither feasible nor ethically appropriate.

Instruments

The instrument used was the learning skills questionnaire which comprised of three sections: Demographics, problem-solving teaching strategies, and problem-solving beliefs. The learning skills questionnaire was developed to determine the teaching methods and strategies for problem-solving by analyzing the modes of thinking for problem-solving (Palraj et al., 2016). In the section on demographics, data on the respondents teaching experience, as well as devices and applications used for communication, searching for information and creating resources for teaching was surveyed. Open-ended questions were used to gather information on the devices and applications used.

In the section on problem-solving teaching strategies, the frequency of use of the strategies in the domains of analogizing, modelling, reasoning causally, and arguing

were investigated (Jonassen, 2013). A 5-point Likert scale was employed to indicate the frequency of using the strategy where 1 indicated never using the strategy, while 2 indicated almost never which meant less than 20% of the time or once in two to three months; 3 was sometimes, which meant it was used about 40% of the time or once in two to three months; 4 was frequently, which meant about 60% of the time or once in two weeks; and 5 was always, or more than 80% of the time or almost every lesson (DeWitt et al., 2018).

In the section on problem-solving beliefs, a 5-point Likert scale was used to indicate their beliefs on each item, which ranged from 1 for don't know, 2 for not true, 3 for true and 4 for very true (Palraj et al., 2015).

This scale was validated structurally (Palraj et al., 2016) and was shown to be reliable as it had a Cronbach's alpha coefficient of 0.931 (Techanamurthy, et al., 2018).

Data Analysis

Quantitative data were analyzed using descriptive statistics, including means (Ms), standard deviations (SDs), and percentages, to summarize overall patterns of instructional practices and teachers' beliefs (Creswell & Creswell, 2018; Fraenkel et al., 2019). M scores were interpreted using equal-interval categorization commonly applied in Likert-scale analysis, whereby values of 1.00-2.33 were classified as low, 2.34-3.66 as moderate, and 3.67-5.00 as high, consistent with established practices in educational and social science research (Pallant, 2016; Vagias, 2006).

RESULTS

The 419 respondents were mainly teachers teaching science (71.8%, n = 301) and at the lower secondary level (73.7%, n = 309) (see **Table 1**). A larger number of the teachers had 6 to 10 years of working experience (33.9%, n = 142), while a smaller proportion had more than 20 years' experience (13.8%, n = 58) (see **Table 1**). Most of the teachers perceived themselves to be moderately skilled in computers (84.0%, n = 352), while a small proportion claimed to be highly skilled in computers (0.5%, n = 2).

Devices and Applications Used by Secondary School Science Teachers

The survey showed that all teachers communicate with mobile phones (100%, n = 419) (see **Table 2**). In addition, all teachers create and share materials using laptops (100%, n = 419) and a large number have desktop computers for this purpose (68.26%, n = 286). Teaching resources were presented mainly through LCD projectors (74.94%, n = 314) and interactive whiteboards (51.07%, n = 214).

Table 1. Profile of respondents

Area		Frequency (n)	Percentage (%)
Subjects taught	Science	301	71.8
	Biology	35	8.4
	Chemistry	30	7.2
	Physics	53	12.6
	Total	419	100
Level taught	Upper secondary	110	26.3
	Lower secondary	309	73.7
	Total	419	100
Teaching experience	0-5 Years	107	25.5
	6-10 Years	142	33.9
	11-20 Years	112	26.7
	More than 20 years	58	13.8
	Total	419	100
Computer skills	Very skilled	2	0.5
	Skilled	10	2.4
	Moderate	352	84.0
	Low	55	13.1
	Total	419	100

Table 2. Devices used by respondents

Area		Frequency (n)	Percentage (%)
Communication	Smartphone	419	100
Creating and sharing resources	Laptop	419	100
Presentations	Desktop/ computer	286	68.26
	LCD projector	314	74.94
	Television	102	24.34
	Interactive whiteboard	214	51.07

Table 3. Educational applications used by respondents

Area		Frequency (n)	Percentage (%)
Communication	WhatsApp	358	85.44
	Telegram	402	95.94
	Google Meet	258	61.58
	Zoom	398	94.99
	Facebook	376	89.74
	Twitter	106	25.30
	Skype	201	47.98
Submission of assignments	Google Classroom	341	81.38
	Microsoft Teams	267	63.72
	Telegram	402	95.94
	Email	211	50.36
Information search	YouTube	301	71.84
	Google	401	95.70
	Translators	164	39.14
	DELIMa	401	95.70
	Science simulations	195	46.54
Creating, sharing and presenting resources	Canva	305	72.79
	Quizizz	264	63.00
	MS PowerPoint	315	75.18
	MS Excel	304	72.55
	Web Quest	185	44.15
	Kahoot	264	63.00
	Scribd	104	24.82
	Slide Share	258	61.58
	Google Form	323	77.09

For communication, text messaging was widely used. The instant messaging application Telegram (95.94%) seemed to be more widely used than WhatsApp (85.44%) (see **Table 3**). This was perhaps due to the capability of Telegram in providing better user experiences, having enhanced security, enabling storage of larger file sizes of the software, and having a maximum number of participants in groups of up to 200,000 members (Yang, 2025, November 6). Teachers also asserted that the district education offices utilized Telegram to transmit information directly to them.

Video conferencing was also used for communication as meetings were conducted on these platforms. Zoom seemed to be used more often (94.99%) compared to Google Meet (61.58%). This advantage was perhaps due to the functionality of Zoom, as it had advanced features for screen sharing, chat, recording, and storage when on the free plan (Gagic, 2025, July 3). Other tools for communication that were frequently used were Facebook and Twitter. Although these are social media tools, they were popular among teachers, with Facebook used by most teachers (89.74%). Facebook appeals to users from various age groups and has a massive "user base" as well as features that make sharing media in an intriguing manner (ExpressVPN, 2025 February 10).

As for students submitting assignments, teachers seemed to prefer Telegram (95.94%). It was possible that all teachers using Telegram had students submitting assignments through this application. Google Classroom was the next most preferred tool, with many teachers also requesting that students use it for assignment submission (81.38%). In designing learning experiences, teachers searched for information with the most popular tool for information search being Google (95.7%) and Digital Educational Learning Initiative, or DELIMa (95.7%). Google was perceived to be a reliable source of information. In addition, teachers preferred to refer to a formally approved channel like DELIMa, as it was a platform provided by the Ministry of Education.

The application that was most used for interacting and creating learning materials by teachers was MS PowerPoint (75.18%), closely followed by Canva (72.79%) (see **Table 3**). Canva seems to encourage students' interest and creativity (Firdayanti et al., 2024). However, interviews with teachers who used Canva showed that teachers used it for creating their own slides and also requested students to use Canva for designing presentations or other materials such as posters. Presentation slides were also shared on platforms such

as SlideShare and were used by a large proportion of teachers (61.58%). Besides these, MS Excel was also a popular tool among teachers (72.55%). This was because teachers used this application to display data from science experiments, and the information could also be converted to graphs and charts for display. In addition, many other interactive tools were also used, such as Kahoot (63.00%) and Quizizz (63.00%). All these tools were made available to teachers at public schools on the DELIMa platform provided by the Ministry of Education.

Problem-Solving Teaching Strategies Used Among Secondary School Science Teachers

The analysis of the problem-solving strategies according to the modes of thinking indicated that teachers applied these strategies at a high level for teaching science (see **Table 4** and **Appendix A**).

Problem-Solving Beliefs Among Secondary School Science Teachers

The analysis of the teachers' beliefs in problem-solving seemed to indicate some misunderstandings of the concept of problem-solving. Strikingly, there was a low level of agreement on "I need to think when I solve problems" (M = 2.07, SD = 0.411), which may indicate that teachers did not perceive that problem-solving required thinking skills (see **Table 5**). There was a misconception that problem-solving included the memorization of facts (M = 3.55, SD = 0.687) and concepts (M = 3.40, SD = 0.737) and was important for learning or that problem-solving was only used in mathematics (M = 3.65, SD = 0.588).

Table 4. Strategies for teaching problem-solving in science

Strategies	M	SD	Level
Analogizing	4.35	0.838	High
Modelling	4.19	1.030	High
Reasoning causally	4.20	0.916	High
Argumentation	4.17	0.928	High

Note. *M scores interpretation: 1.00-2.33 = low, 2.34-3.66 = moderate, & 3.67-5.00 = high

Although the teaching strategy of making analogies was high (M = 4.35, SD = 0.838), teachers only had a moderate level of agreement/ uncertainty on applying concepts to other situations being important (M = 3.39, SD = 0.769), indicating a discrepancy in the results.

DISCUSSION

The integration of digital tools in Malaysian science classrooms should be the foundation for fostering problem-solving skills. In this study, all 419 teachers reported using laptops and smartphones for instructional purposes, with 95.94% utilizing Telegram and 94.99% using Zoom for communication and instructional delivery. Tools like Google, DELIMa, Canva, and PowerPoint were commonly employed to develop and share learning materials. This widespread use of digital platforms suggests a strong infrastructure and willingness among teachers to embrace technology in support of student learning. This provides a strong foundation for the development of cognitive engagement among students, as it enables the application of learned concepts, the visualization of intricate relationships, and the development of meaningful knowledge within the field (DeWitt & Alias, 2024; Jonassen, 2013; Pinto & Leite, 2020).

Table 5. Beliefs in problem-solving in science

No	Strategies	M	SD	Level
1	I solve problems in my everyday life.	3.62	0.485	Moderate
2	Problem-solving is needed in everyday life.	3.63	0.580	Moderate
3	Problem-solving provides a purpose for learning.	3.65	0.532	Moderate
4	Problem-solving is a useful skill.	3.65	0.546	Moderate
5	Problem-solving is only used in mathematics.	3.65	0.588	Moderate
6	I need to think when I solve problems.	2.07	0.411	Low
7	Learning facts is important for gaining knowledge.	3.54	0.637	Moderate
8	Memorizing facts is important for learning.	3.55	0.687	Moderate
9	Memorizing concepts is important for learning.	3.40	0.737	Moderate
10	Applying concepts to other situations is important for learning.	3.39	0.769	Moderate
11	I can usually find an answer when I use problem-solving.	3.67	0.507	Moderate
12	I enjoy problem-solving activities.	3.52	0.608	Moderate
13	Learning through problem-solving is more meaningful than learning facts.	3.50	0.657	Moderate
14	Learning through problem-solving is more effective.	3.51	0.653	Moderate
15	Knowledge learned through problem-solving is more effectively remembered.	3.73	0.466	High
16	Knowledge used for problem-solving can be transferred easily to other problems.	3.56	0.624	Moderate
17	Knowledge that is constructed while solving problems becomes more meaningful.	3.49	0.661	Moderate
18	Knowledge that is constructed while solving problems is deeper.	3.55	0.648	Moderate
19	Problem-based learning* results in higher levels of problem-based learning*, which results in higher levels of understanding than traditional teacher-centered instruction.	3.54	0.674	Moderate

Note. *Mean scores interpretation: 1.00-2.33 = low, 2.34-3.66 = moderate, & 3.67-5.00 = high

Interestingly, the data revealed a substantial discrepancy between the teachers' beliefs on problem-solving and their instructional practices, despite the encouraging technological integration. The findings suggested that the teachers employ all four modes of thinking that are essential for problem-solving pedagogy: analogizing (M = 4.35, SD = 0.838), modeling (M = 4.19, SD = 1.03), causal reasoning (M = 4.20, SD = 0.916), and argumentation (M = 4.17, SD = 0.928). These findings suggest that teachers are proficient in the implementation of cognitively rich strategies that are consistent with Jonassen's (2013) first principles of learning. Nevertheless, the results of the study revealed that their conviction regarding the significance of applying concepts to novel contexts was only moderate (M = 3.39, SD = 0.769). Consequently, these practices were not consistent with their beliefs. This indicates that the teachers possibly have a limited depth of comprehension or application of problem-solving strategies in science.

More importantly, it was found that the teachers' beliefs on the importance of taking a deeper thinking in solving a problem was found to be low (M = 2.07, SD = 0.411). This suggests that there is a potential fallacy that problem-solving is not a cognitively requiring process. Additionally, a significant number of teachers believed that the acquisition of scientific knowledge was primarily dependent on the memorization of facts (M = 3.55, SD = 0.648) and concepts (M = 3.40, SD = 0.737), which indicate a traditional, didactic teaching approach. The development of students' higher-order thinking may be inadvertently impeded by such beliefs, which reduce science to content acquisition rather than inquiry and reasoning (Chalkiadaki, 2018; Dewi et al., 2023; Rahmawati et al., 2022). These misconceptions are consistent with the concerns that have been expressed in previous research, which indicates that teachers frequently encounter difficulties in incorporating critical thinking because of a lack of defined frameworks or support (Changwong et al., 2018; Gul & Akcay, 2020). Teachers seem to neglect the concept of science as a process of inquiry and problem-solving.

This gap between what teachers believe and what they practice highlights a key challenge in science education reform. Although many teachers appear to use modern teaching strategies, their core beliefs still reflect a focus on delivering content rather than developing thinking skills. Since teachers' beliefs strongly influence how they teach (Gregoire, 2003; Watson, 2015), this mismatch is a cause of concern. This may indicate that science teachers believed that a traditional approach was useful for teaching science and that solving problems was less important in science. Simply using certain strategies is not enough as the teachers also need to understand and embrace the thinking skills that are relevant to this subject. Without this alignment, even well-meaning efforts may fall short

in truly helping students become effective problem-solvers (Hmelo-Silver et al., 2013; Jonassen & Kim, 2010).

In short, there is clear evidence of technological readiness and strategic engagement with problem-solving instruction. However, to truly elevate students' scientific reasoning, professional development programs must be restructured to challenge entrenched beliefs and promote an integrated understanding of science as a process of inquiry and problem-solving. As Malaysia continues to grapple with declining PISA scores in science (OECD, 2019, 2023), this alignment between teacher belief and practice will be crucial in cultivating the kind of scientific thinkers the country needs in the era of Industry 5.0 (Adel, 2022; Barata & Kayser, 2023).

The findings extend Jonassen's (1996) mindtools framework by showing that although teachers report frequent use of instructional strategies aligned with the four modes of thinking, these practices are not consistently supported by corresponding epistemological beliefs about problem-solving and learning. This misalignment indicates that the application of problem-solving strategies may, in some instances, be procedural rather than conceptually grounded, where strategies are enacted as instructional routines without a clear understanding of their intended cognitive purposes. As a result, the presence of cognitively oriented practices does not necessarily reflect a deeper commitment to problem-solving as a core epistemic activity in science learning.

This pattern of belief-practice incongruence is consistent with prior research, which has shown that teachers may adopt innovative or higher-order instructional strategies while retaining traditional beliefs centered on content transmission and memorization (Gregoire, 2003; Pajares, 1992). When such beliefs remain unexamined, instructional practices risk becoming surface-level, thereby limiting their capacity to promote sustained problem-solving and higher-order thinking (Hmelo-Silver et al., 2013; Watson, 2015). Consequently, these findings reinforce the view that effective problem-solving instruction requires more than pedagogical training or access to digital tools alone. Meaningful integration of cognitive mindtools depends on belief transformation that reconceptualizes problem-solving as a cognitively demanding, epistemic process, supported by professional development initiatives that explicitly address teachers' beliefs about knowledge, thinking, and learning (Jonassen & Kim, 2010; McNeill et al., 2016).

CONCLUSIONS

In conclusion, this study provides important insights into how science teachers in Malaysian secondary schools use digital tools, apply problem-solving strategies, and what they believe about teaching problem-solving. While teachers are actively using a

wide range of digital platforms and report frequent use of strategies like analogizing, modelling, reasoning, and argumentation, there seems to be a disconnect between what they do and what they believe. Many still view problem-solving as a task that doesn't require deep thinking, and often associate science learning with memorizing facts and concepts. These beliefs, if left unaddressed, may limit students' opportunities to develop meaningful scientific reasoning and higher-order thinking skills.

The study indicates there is technological readiness among teachers as there is widespread use of digital applications which suggests a strong infrastructure and willingness among teachers to embrace technology as mindtools for the development of cognitive skills for analogizing, modelling, reasoning causally, and arguing within the field. However, teachers' beliefs in problem-solving could influence their method of teaching.

What this suggests is that efforts to improve science education cannot stop at introducing tools or methods alone. There must also be supported to help teachers shift their mindset about what problem-solving in science truly involves. In addition to strategy training, professional development should emphasize the enhancement of teachers' comprehension of the ways in which these strategies facilitate more profound thinking. It is essential to ensure that teaching genuinely leads to learning by aligning beliefs with practice.

The findings are significant as they indicate a distinct misalignment between beliefs and practices: teachers may claim to utilize problem-solving routines and digital platforms yet continue to prioritize memorization or approach problem-solving as procedural rather than cognitively challenging (Pajares, 1992; Palraj et al., 2015; Watson, 2015). This is significant as educators' perceptions influence pedagogical judgement and the extent of classroom implementation (Pajares, 1992; Watson, 2015). Analyzed from a mindtools perspective, the findings confirm that technology is significant when it facilitates learners' reasoning, modeling, and justification, rather than when it serves only as a means of material delivery (DeWitt & Alias, 2024; Jonassen, 1996, 2013). The study establishes a solid foundation for professional development that combines tool use with explicit scaffolding of inquiry, explanation, and argumentation in scientific problem-solving (Hmelo-Silver et al., 2013; Jonassen & Kim, 2010; McNeill et al., 2016).

Future research should employ mixed-method designs and classroom-based observations to triangulate self-reported practices and capture actual cognitive engagement. Longitudinal studies examining belief change following targeted professional development would further strengthen understanding of how digital mindtools can be effectively integrated into science problem-solving pedagogy.

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APPENDIX A

Table A1. Supplementary data

No		M	SD	Level
Analogizing				
1	Compare similar problems or cases to find common principles in the method of answering the question.	4.36	.803	High
2	Compare similar problems or cases that been done in class.	4.43	.765	High
3	Organize the ideas presented when solving a problem.	4.49	.686	High
4	Use ICT tools or software to organize the ideas.	4.26	.943	High
5	Use ICT tools, such as graphics, graphic organizers, and mind maps.	4.22	.987	High
6	Compare similar problems or cases to find common principles in the method of answering the question.	4.36	.803	High
Modelling				
7	Use ICT tools or software to show relationships between the concepts.	4.29	.950	High
8	Use ICT tools or software to construct a model.	4.08	1.102	High
9	View interactive simulations or other ICT resources to show relationships between concepts.	4.19	1.032	High
Causal reasoning				
10	Find relationships between the concepts.	4.27	.927	High
11	Construct a model in your mind (a mental model) to show the relationship between concepts.	4.25	.954	High
12	Change the relationship between concepts to see the results.	4.15	.993	High
13	Make predictions to forecast the answer.	4.25	.941	High
14	Discuss the implications when a variable is changed.	4.30	.850	High
15	Find the effect of changing different variables.	4.22	.941	High
16	Test the predictions made.	4.18	.976	High
17	Guess the answer.	4.05	1.092	High
18	Use a real-life situation to test the answer.	4.23	.909	High
19	Experiment with the mental model of the case to solve the problem.	4.30	.846	High
20	Focus only on important points in a complex question.	4.00	1.115	High
21	Answer a complex question by writing the answers, step by step.	4.24	.904	High
Argumentation				
22	Ask questions to find important aspects on which to focus.	4.16	.935	High
23	Answer a complex question and justify each of the steps in the answer.	4.18	.893	High
24	Consider several possible answers.	4.23	.896	High
25	Consider different methods and approaches to obtain answers.	4.19	.939	High

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