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Supporting secondary school science teachers to teach science inquiry skills

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Abstract
Curricula worldwide include Science Inquiry Skills (SIS), yet teachers face challenges in teaching these skills due to vague curriculum guidelines and limited resources. With limited research and guidance for teaching SIS, this study aimed to identify and understand the factors influencing practicing teachers to determine useful approaches for support. This qualitative study of 18 teachers working in Australian schools, took place during 2023. Data collection involved a survey study with open-ended questions, and thematic analysis, determined the enablers and inhibitors for teaching SIS. Enablers include other people, past experiences and varied resources, while inhibitors were inadequate curriculum guidance, insufficient resources and time constraints. The research suggests a range of strategies for supporting teachers in developing their skills to teach SIS and enhancing student learning. These findings could help improve teacher education, professional development and school leadership support, bridging the gap between curriculum expectations and classroom practices in teaching SIS. By addressing these challenges, educators can better equip students with the critical thinking and scientific inquiry skills necessary for informed decision-making in an increasingly complex world.

Keywords: science teaching, science inquiry skills, teacher learning, professional learning, enablers and inhibitors

INTRODUCTION

Living in the 21st century is complex and requires individuals to be critically literate, to enable informed decisions and subsequent behaviour. To be scientifically literate (Rudolph, 2024) means not only understanding basic scientific knowledge, but also having skills related to science inquiry, such as questioning, predicting, modelling, and designing and conducting experiments (Osborne, 2013). To ensure the next generation is well-prepared for navigating their world, many countries have adopted an approach in their science curricula that includes skills designed to build scientific inquiry. For example, The Singapore Science Curriculum Framework focuses on scientific inquiry defining three key areas of practice: knowledge, understanding, and application; skills and processes; and ethics and attitudes (Mullis et al., 2016), while in Norway, the focus in upper primary and lower secondary school science is on students as researchers; formulating questions, planning and conducting investigations, testing hypotheses and communicating their results (Mullis et al., 2016).

Despite global differences in nomenclature, skills that build scientific inquiry commonly include practices such as *questioning and predicting; planning and conducting; processing and analysing data and information; evaluating;* and *communicating* (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2018; Ministry of Education Singapore, 2021; National Research Council, 2000; Next Generation Science Standards (NGSS) Lead States, 2017). To develop scientifically literate students, teachers need to include these Science Inquiry Skills (SIS) in their lessons; however, this can be challenging for teachers (Akuma & Callaghan, 2019). This difficulty stems from several factors. First, science curricula typically outline required SIS but provide insufficient instructions on how to develop these skills in students. Second, teachers need both personal proficiency in SIS and specialised knowledge on how to teach these skills effectively. Although some studies have investigated

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Contribution to the literature

- This study identifies specific enablers and inhibitors that influence secondary science teachers' ability to to teach Science Inquiry Skills (SIS), addressing a gap in understanding the factors affecting SIS teaching beyond inquiry- and argumentation- based approaches.
- The research shows that effective SIS teaching requires diverse resources, collaborative communities of practice, and consideration of student perspectives, while highlighting challenges related to planning, student engagement, and time constraints.
- Based on the findings, the paper provides practical recommendations for supporting teachers in SIS instruction, such as the provision of more detailed curriculum guidance, adaptable resources and targeted professional development opportunities, as well as the facilitation of collaborative learning groups.

inquiry- and argumentation- based teachings, a third challenge lies in the limited understanding of what specifically promotes or impedes SIS teaching, and what support teachers need for success in this area. These challenges can potentially impact students' skill development and overall scientific literacy, illustrating the need to develop understanding of how to further support teachers.

Aiming to develop this much needed understanding, this research seeks to identify the specific inhibitors teachers encounter when teaching SIS, investigate the types of support and resources teachers need to overcome these challenges, and suggest evidence-based strategies and recommendations to enhance teachers' ability to effectively integrate SIS into their science lessons. By addressing these issues, this study aims to contribute to the improvement of SIS instruction and, consequently, the development of scientifically literate students.

LITERATURE REVIEW

Science Inquiry Skills (SIS)

SIS are integrally tied to the development of scientific literacy and include activities such as 'asking scientific questions, designing investigations, using and constructing scientific models, collecting and analysing data, generating and evaluating evidence-based arguments, recognizing (and evaluating) alternative explanations and uncertainties, and generating explanatory and inferential representations' (Schwartz et al., 2023, p. 6). However, the term SIS is not used universally, nor should it be confused with science inquiry as a pedagogical approach; the latter can promote the development of SIS but may also be aimed at understanding science knowledge or the Nature of science. In Australian curriculum documents, SIS includes *questioning and predicting*; *planning and conducting*; *processing and analysing data and information; evaluating*; and *communicating* (ACARA, 2018), whereas in the United States, similar skills are identified as Science and Engineering Practices (NGSS Lead States, 2013). These practices align with Australian SIS but also make more explicit elements such as *developing and using models, using mathematics and computational thinking* and *engaging in argument from evidence.* While the focus of SIS is generally agreed upon across different countries, the detail of what is required in the curriculum differs between countries.

Science process skills is a commonly used term in Türkiye, referring to capacity for defining problems, observing, analysing, hypothesising, investigating, concluding, generalising and applying everyday scientific information (Aktamis & Ergin, 2008). In the German biology education standards for secondary schools, one of four science competence areas is scientific reasoning, including areas such as *Develop questions and hypotheses based on observations and theories*, and *interpret and reflect on inquiry processes and results* (KMK, 2020). While different terms exist, SIS essentially refer to a set of inquiry practices that students experience during their science education, expanding their ability in critical and creative thinking, problem solving and drawing conclusions using scientific methods; the core of scientific literacy (Osborne, 2013).

Teaching science inquiry skills (SIS)

Effective teaching is central to the development of SIS. Constructivist teaching approaches such as investigation, inquiry and argumentation (Bybee, 2006; Gultepe & Kilic, 2015; Turiman et al., 2012), which involve active participation of students, are commonly employed in schools to develop SIS. Additionally, research identifies the use of scaffolds to support student learning, including explicit instruction (Kruit et al., 2018), reflecting on the ways of conducting investigative activities (Dunlop et al., 2020), and discourse generated by teacher questioning (Schwartz et al., 2023). Stevenson et al. (2024) note that teachers often use a variety of strategies (e.g., context-based learning, modelling, explicit teaching, peer review) when teaching SIS, with different strategies used for different skill development. For example, models and modelling are useful when students are learning about aim, hypothesis, method to help them visualise a skill, while explicit teaching was commonly used to teach the mathematical skills required when communicating findings. This research highlights that there are a variety of different approaches to teaching SIS.

While contemporary science education now commonly involves more class time spent on SIS, students enter secondary school with minimal understanding of scientific inquiry (Lederman et al., 2019) and are still 'naive' about the inquiry process (Lederman et al., 2021). This indicates that there are likely challenges with SIS teaching and learning that need to be determined, understood, and support strategies identified. Identifying the support needed to teach SIS involves understanding its influencing factors, enablers and inhibitors. A range of barriers affecting teaching SIS have been identified, including lack of time for resource development and classroom implementation in already dense curricula (Akuma & Gaigher, 2021; Fitzgerald et al., 2017), as well as limited teacher understanding of scientific inquiry (Krell et al., 2020) and its practical classroom application (Herranen & Aksela, 2019; Kaya et al., 2020), compounded by poor quality professional development (Fitzgerald et al., 2017). Other research has revealed enablers which support inquiry- and argumentation- based teaching including collaborative science teacher learning communities (Lotter et al., 2014), access to high quality instructional materials and resources (McNeill et al., 2016), sustained, science-specific professional development (Capps et al., 2012; Ramnarain et al., 2022) and experiencing inquiry-based learning as a preservice teacher (Strat et al., 2023). Without a focus specifically on SIS, Navy et al. (2020) found that teachers generally rely on a variety of human, material and social resources, from which social resources are particularly important. While these are valuable influences to consider, inquiry and argumentation are only two of the approaches used in SIS teaching (Stevenson et al., 2024); there are likely further inhibitors and enablers, associated with other teaching approaches, yet to be identified. Understanding this broader range of influencing factors is important for identifying the type of support that is needed for teaching SIS in a variety of different ways. However, there has been limited research into the factors affecting the teaching of SIS. This study investigates the inhibitors and enablers facing teachers, to enhance understanding of how to support SIS teaching and learning. Investigating these factors will provide valuable insights to design and tailor Initial Teacher Education and Professional Learning programs, to address science teacher needs, and guide school leaders in their supporting strategies.

MATERIALS AND METHOD

Aiming to identify and understand the factors that influence science teachers' planning and implementation of SIS, a qualitative study was chosen as it enabled the in-depth exploration of complex situations such as teaching SIS (Merriam & Tisdell, 2016). By exploring the perceptions of current science teachers, it was possible to gather insight into the research question:

RQ1 What are the enablers and inhibitors that influence science teachers' planning and teaching of SIS?

Research Context

This study was undertaken in the state of Victoria, Australia in which schools can use either the Australian Curriculum (ACARA, 2018) or the Victorian Curriculum (VCAA, 2016) to guide their teaching of SIS. In these curricula, SIS are considered a separate yet complementary thread to science understanding (e.g., disciplinary knowledge). These curricula act as a guide for teachers, but do not offer explicit planning and implementation instructions, meaning that SIS receive varied attention in schools.

Recruitment of Participants

Following ethics approval from the University of Melbourne Human Research Ethics Committee (2023, Ethics ID Number: 26967), secondary science teachers in Victoria were invited to contribute to the study. A survey with open-ended questions was used for this study because it provided deeper insights into teachers' perceptions of the influences on teaching SIS without being burdensome on teachers' already limited time. Given secondary school science education in Australia starts at year 7, our focus was on the views of Year 7 and 8 science teachers as we wanted to understand how teachers were supporting students in these initial learning experiences. Recruitment occurred via emails to existing networks of teachers and advertising through the websites and newsletters of Science Teachers Association of Victoria (STAV). Interested teachers provided written consent for participation through an online survey, where additional information about the study was offered through a plain language statement. Information regarding confidentiality and the voluntary nature of the study was provided at the start of the qualitative survey and eighteen teachers gave their perceptions of the factors influencing their teaching of SIS. The participants completed the survey between August and October 2023, and pseudonyms (e.g., Teacher 1, Teacher 2) were used in the findings to ensure the maintenance of privacy.

Participant Demographics

Fourteen of the 18 participants were currently teaching a Year 7 and/or Year 8 science class. The remaining four had taught Year 7 and/or Year 8 previously. Participant experience varied widely, with eight having less than five years, five having more than 14 years and the remaining having between five and 14 years of teaching experience. Fifteen of the participants were teaching in metropolitan schools with the

Table 1. Illustration of categories of enablers and inhibitors with description and data examples

Influences	Description	Example
		Enablers
People	Other individuals that teachers have contact with and learn from	'Other teachers' (Teacher 2) 'Other teacher groups outside of work' (Teacher 8)
Experiences	Encounters in teachers' lives which support their SIS teaching	'... professional learning, science textbooks - although nearly everything needs to be adapted to fit the context and learning levels of my students. I also draw on my experiences from my past life as a research scientist. (Teacher 10)
Resources	Support materials that provide teachers with insights into how to teach SIS	'The school's resources' (Teacher 14) 'Websites, science textbooks' (Teacher 12)
		Inhibitors
Teaching-related Challenges	Difficulties associated with planning and implementing SIS teaching	'School expectations/culture biased towards traditional instruction' (Teacher 5)
Student-Related Challenges	Difficulties associated with teaching SIS that arise from student obstacles	'They [the students] struggle to get to investigate a very specific component and how to eliminate the extraneous information. They also struggle to analyse trends' (Teacher 17)
Time	Challenges arising from temporal constraints	'Patience/ Time' (Teacher 7)

remaining three participants in rural locations. Fifteen of the participants had experience with science inquiry in their previous study or employment.

Data Collection and Analysis

Data was collected through a survey developed from our literature review of research which illustrated variation in defining SIS, teaching strategies and limited influencing factors. As part of a larger study aimed at exploring teachers' professional knowledge and practices related to teaching SIS (Stevenson et al., 2024), the survey included a range of questions, such as 'is your school located in a metropolitan, regional or rural location?' and open-ended questions including 'what are your challenges in developing students' inquiry skills?'. **Appendix A** illustrates the full set of survey questions, however, in this paper, we focus on the enablers and inhibitors. The survey questions enabled participating teachers to provide open responses, allowing them to identify more than one factor enabling or inhibiting their teaching of SIS, if appropriate.

The survey data was analysed through an iterative series of steps. Firstly, survey responses were deductively organised by each researcher individually, according to whether they were enablers or inhibitors influencing the planning and teaching of SIS. Data organisation was followed by descriptive coding of each individual enabler and inhibitor (Miles et al., 2014). To support the reliability of our interpretations (Merriam & Tisdell, 2016), coding of each response was completed individually by the first and second authors, then discussed between researchers until consensus was reached. The final coding allowed us to create categories of enablers and inhibitors based on similarity. Once the categories and sub-categories were developed, researchers returned to the data set to reflect on, discuss and verify them. Following Miles et al. (2014), we conducted a thorough review of the survey data, scrutinising our codes and themes to explore possible alternative interpretations. An illustration of the categories, a description of what they include, and data example can be seen in **Table 1**.

Given the qualitative nature of this study, several steps were taken to ensure trustworthiness (validity) of data analysis and the conclusions drawn (Merriam & Tisdell, 2016). Firstly, to confirm the quality of the research undertaken (Lincoln & Guba, 1985), the methodological steps have been presented throughout this section, highlighting how data was collected and analysed, providing transparency and allowing readers to evaluate the rigour of the study. Secondly, multiple data examples are provided in **Table 1** and the results section to demonstrate interpretations made, helping to illustrate the credibility of the findings. Additionally, the authors acknowledge their positionality as members of a Faculty of Education with a vested interest in science education and teacher education. Recognising that this may bias interpretation of data, the first and second author separately grouped, coded and categorised the survey data, and discussed any discrepancies until consensus was reached.

RESULTS

Using identified categories as a framework, these findings illustrate the types of influences supporting or constraining the teaching of SIS through reporting the frequencies of responses.

Enablers Supporting the Effective Teaching of Science Inquiry Skills

Survey participants identified a wide range of enablers supporting their teaching. These were

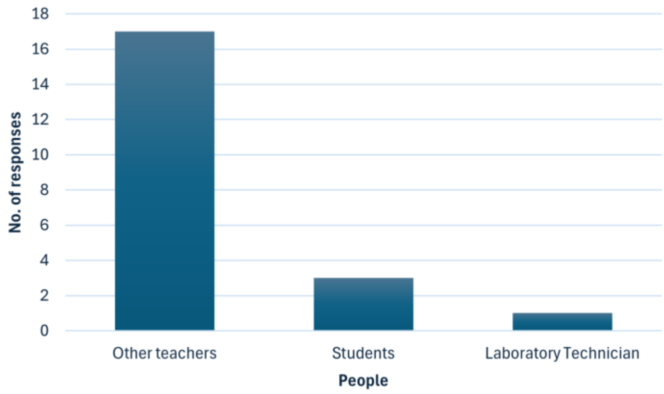

Figure 1. Number of responses for each sub-category in the category people (Source: Authors' own elaboration)

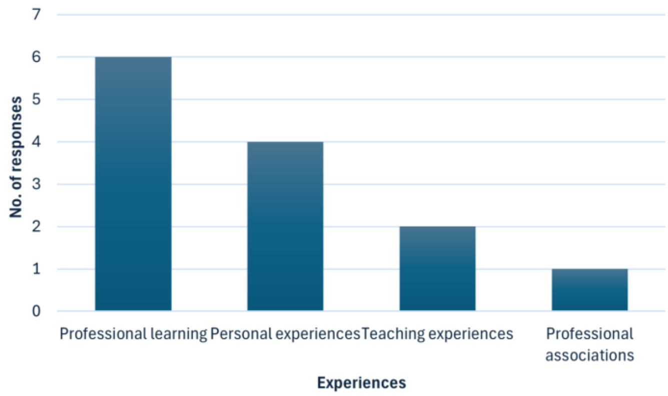

Figure 2. Number of responses for each sub-category in the category experiences (Source: Authors' own elaboration)

categorised as people, experiences and school resources. Within these three main categories, participants identified specific factors (e.g., sub-categories) that facilitated their teaching, as illustrated throughout this section.

People

People were identified 21 times by the 18 participants in this study; yet different types of people were noted as enablers with three sub-categories (i.e., other teachers, students, lab technician) emerging from the analysis, as presented in **Figure 1**.

Overwhelmingly, other teachers were seen as the key enabler with 17 of the 18 teachers identifying it as enhancing their teaching of SIS. They did this by providing resources, ideas and affective support. Participants commented about *working collaboratively with other teachers* (Teacher 8) which helped them to share resources and discuss pedagogies for teaching SIS. This sharing of ideas and resources with other teachers often occurred at the curriculum planning stage. For example, Teacher 14 noted that they obtained ideas *from other teachers who have experience in this teaching context.* More formalised planning came from team meetings at the faculty and year level:

> Teacher 1: Within the knowledge and resources used and shared within our Coaching and Planning Team (CPT)

> Teacher 7: Professional learning communities in real time is best for me.

Participants recognised and appreciated the value of gathering, sharing and discussing their teaching practices, specifically for teaching SIS, with their peers.

Figure 1 also identifies that the laboratory technician was a support for one participant in their teaching of SIS, while three teachers considered students a valuable source of inspiration for teaching SIS, gathering their perspectives during *conversations in the classroom* (Teacher 6).

Experiences

Participants also identified experiences as enabling their SIS teaching, with 13 responses recorded in the survey. Participants suggested a range of different experiences as enabling their teaching of SIS, identified as sub-categories. These are presented in **Figure 2**.

The sub-category of professional learning was quoted six times as enhancing the teaching of SIS. Recognising these as formalised programs delivered by external providers, professional learning offered resources, pedagogies and ideas for contemporary and real-world topics that could be investigated.

Beyond professional learning experiences teachers noted that they drew on their personal and previous study and work:

> Teacher 10: I also draw on my experiences from my past life as a research scientist

> Teacher 11: My life... I love seeing the science in everything and then creating opportunities for students to do it too.

These quotes highlight that personal experiences are useful in providing context and approaches for engaging students in science inquiry.

Other experiences identified by participants included those provided by professional teaching associations such as the Science Teachers' Association of Victoria (STAV), the Victorian Physics Teachers' Association (VicPhysics) and the Mathematics Association of Victoria (MAV). For one teacher, who had been teaching for 30 years, their longevity in the classroom provided them with approaches to *source an investigation out of whatever I can find in the prep room* (Teacher 5). For another teacher, their inspiration came from within:

> Teacher 16: I'm just using my own questions and experiences, especially those that appear spontaneously when I'm teaching or talking with others.

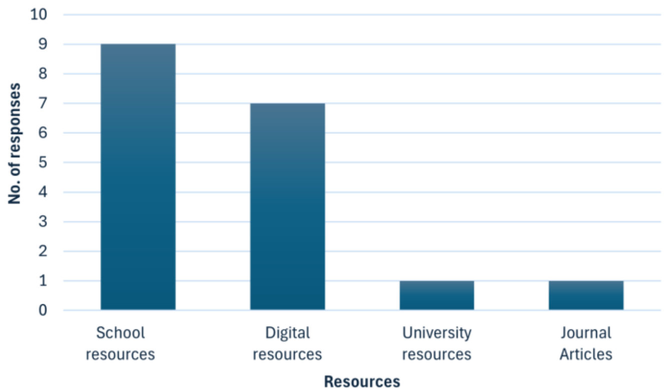

Figure 3. Number of responses for each sub-category in the category resources (Source: Authors' own elaboration)

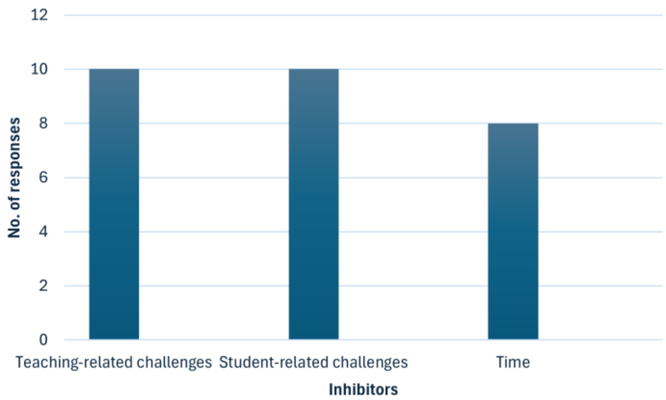

Figure 4. Number of responses for each category of teaching related challenges (Source: Authors' own elaboration)

Previous teaching experiences provided confidence, context, ideas and methods to implement SIS in the classroom. The varied nature of these experiences indicates that more than one approach is used by teachers to develop and plan for teaching these skills.

Resources

Teachers also identified several different resources as being enablers for their teaching of SIS, as indicated in **Figure 3**.

School resources including textbooks and digital resources including websites were frequently identified as enablers, with 16 of the 18 responses in this category relating to these two sub-categories. Teacher 15 found *the Royal Society of Chemistry website* valuable, while Teacher 2 noted the importance of gathering science articles from *Science Alert or a similar contemporary science site.* Knowing that these websites are credible science resources, and the efficiency of using a search engine, provided teachers with easy access to teaching content and approaches to build into SIS lessons. Participants often identified a range of resources:

> Teacher 10: Websites, science textbooks - although nearly everything needs to be adapted to fit the context and learning levels of my students.

Access and availability possibly contributed to the number of resources used by individuals; however, teachers appeared to gather inspiration from more than one source noting that resources were not always ready for immediate use but needed to be adapted to suit their individual context.

Teachers also used enablers from across the categories (people, experiences and resources).

> Teacher 14: Other teachers are supplemented with websites or online educational sources (e.g. Stile).

This indicates that teaching SIS benefits from a broad range of resource use.

Inhibitors Influencing the Effective Teaching of Science Inquiry Skills

Survey participants identified a range of factors inhibiting their teaching of SIS. These were categorised as challenges related to planning for learning, to school students, and time as seen in **Figure 4**. This section illustrates how these factors impeded SIS teaching.

Teaching related challenges

The difficulty of planning tasks that showed the relevance of SIS were identified as a challenge for teachers. Teacher 14 highlighted that their students struggled in *perceiving inquiry skills to be of direct use, thus [of] benefit to their lives.* This comment indicates the importance of relating SIS learning to real-life and age-appropriate contexts and the challenge of sourcing varied issues, problems and contexts to continually reinforce the value of SIS in students' lives. Another teacher noted the challenge of planning intriguing activities which encouraged a sense of wonder for their students:

> Teacher 13: Engendering a sense of curiosity in some students can be challenging... making students curious about a phenomenon and making meaningful inquiry can be tricky.

This teacher identified the importance of engaging students and stimulating their interest. To engender curiosity requires teachers to draw on a range of contexts, examples and issues to ensure all students have an entry point into the topic. Teacher 13 also noted the importance of *meaningful inquiry*, to identify a range of different activities for a diverse student population. Apart from differentiating the context, teaching SIS provided challenges for teachers in both process and content. Teacher 1 recognised that it is *difficult to match cognitive load of tasks to students' capabilities,* noting the challenges of planning the multiple areas of knowledge and skills required in learning about SIS. Aligning these to the context, and different students' levels of understanding were identified as requiring tailored approaches to meet the varied needs of individual students.

A further planning challenge related to teacher knowledge of the learning progression for SIS development.

> Teacher 10: I feel like I sometimes don't have as much of an understanding of how I would expect skills to develop - such as the 'learning progression', which means that it can be difficult to figure out how to explicitly teach the next level of understanding for students... I think the Victorian Curriculum (and most curricula) could also be more explicit in defining individual skills as well as the expected level of achievement... there really isn't any guidance about what this should look like and so much of it is left up to teacher judgement as well as all the time it takes for teachers to figure out what this should look like.

Teacher 10 noted the difficulty of planning the next steps for students learning of SIS, either within a class or between year levels, especially when curriculum guidance was limited.

Student-related challenges

In contrast to teacher-related difficulties in planning for learning SIS, teachers identified inhibitors associated with their students. One teacher noted that their students imagined more expansive tasks than could realistically be achieved in the allotted time frame.

> Teacher2: Having students feel satisfied with smaller projects and outcomes- they often think too big, and it is difficult to keep their goals realistic for what is achievable in the 3-4 lessons we must design and run the experiments.

Student satisfaction was maximised if they could design tasks that were interesting and realistic in scope both in the size of the task and time available for completion. However, according to Teacher 16, some students had difficulties remaining engaged in their project over a period and were likely to lose interest before task completion.

> Teacher 16: I think the biggest challenge is keeping a focus on the end goal - which is to come to some sort of resolution of the initial stimulus problem that was set... I think for students it is very easy to be satisfied very early on... So, there's a challenge with students' dispositions away from perseverance, dissatisfaction.

Successful completion of SIS investigations required students to focus, persist and overcome any engagement hurdles.

Academic challenges were also highlighted as difficult for students due to the complex nature of learning SIS:

> Teacher 5: The challenge I find is that there are so many skills needed all at once, and it can be a bit overwhelming for the students even though we take it step by step. Collecting data is straightforward, but the graphing of the data takes a lot out of the kids.

Teacher 5 recognised that students needed numeracy skills to undertake SIS, particularly for analysis and presentation of data. Challenges arose when students lacked these skills, resulting in them being overwhelmed, losing confidence and interest and, for some students, *off task behaviours, not tuning into the topics* (Teacher 3). Teachers also reported that students with low literacy skills struggled to engage with SIS learning.

> Teacher 14: At my school for year 8 this [literacy] ranges from the level of a 5-year-old to that of an early teenager.

Literacy is a key component of SIS in the discussion and communication of findings, however, for students with low literacy levels, understanding SIS is likely to be challenging. A further academic challenge lay in students' science content knowledge as:

> Teacher 10: There's often scientific content that needs to be understood to be able to apply an inquiry skill well (or correctly). For example, when learning about variables, a student might be able to define variables and demonstrate this understanding, but they might have difficulty applying them in particular science disciplines like a physics experiment investigating friction but have no trouble applying them in a biology experiment investigating plant growth.

Here the challenge lies in students' difficulties applying skills from one context to another. While not explained here, it could be argued that this challenge resulted from students' limited recognition, interest or knowledge of the transferability of SIS skills across science disciplines. This is complicated by the fact that

SIS are applied in two different domains (friction/plant growth) and students could have different levels of knowledge and interest in those domains

Time

Eight teachers commented on time constraints as an inhibitor when teaching SIS and, on occasion, explained why this was a challenge. Concerns about available time for planning and implementation were indicated with Teacher 10 noting that teaching SIS was *time consuming.* Teacher 7 also noted the challenge of finding time since they needed to convince other teachers and leaders *to give me space and time within [the] curriculum to do this.* With increased focus on teacher workload, high levels of administration and the current teacher shortage, finding time and other teachers to allow considered and reflective collaborative planning and development of SIS is a significant challenge in today's schools.

DISCUSSION

With scientific literacy an educational priority across many countries, the teaching of SIS has become a critical aspect of science education. Science curricula require teachers to teach SIS; however, much of the curriculum detail is limited (ACARA, 2018; Ministry of Education Singapore, 2021; National Research Council, 2000; NGSS, 2013). Successful teaching requires teachers to develop effective and engaging experiences for their students (Hattie, 2008) and feel confident in doing so (Nolan & Molla, 2017). Successful teaching of SIS needs guidance and explicit instruction for students, particularly when undertaking science inquiry as a pedagogy (Vorholzer & von Aufschnaiter, 2019). While research has explored the factors influencing inquiry- and argumentation- based teaching, there is limited understanding of the enablers and inhibitors affecting the broader context of SIS teaching and the support that teachers need to be effective. Our study illuminates the factors impacting SIS teaching in secondary schools and identifies necessary support types.

This study reveals that SIS teaching requires diverse resources, including school, digital and university materials as well as relevant journal articles. While high quality instructional resources and materials are key to inquiry-based teaching (McNeill et al., 2016); it was found that resource diversity is valuable for maintaining student engagement in SIS. For example, the real-life contexts used in SIS teaching must be relevant and compelling for individual students to maintain their interest (Stevenson et al., 2024) as students engage more with topics that are meaningful to them (Moore et al., 2015). However, teachers need a variety of resources to plan for a range of investigations and accessing these resources may be challenging. Additionally, teachers need to see the value in the resources provided, to ensure their use (Navy et al., 2020).

Teachers reported that having diverse SIS teaching resources supported differentiation in their classes, helping meet diverse student abilities in literacy and numeracy. For example, consulting both digital and text-based resources provided multiple interpretations and opportunities to plan, design and implement varied experiences that aim to develop their SIS, and support varied student needs. By allowing students to interact with science (e.g., content and/or skills) in ways that suits their cognitive levels and strengths, a multimodal approach enhances accessibility (Rose & Meyer, 2002) and comprehension (Ainsworth, 2006). Furthermore, teachers must carefully consider the degree of openness (i.e., the extent of students being engaged in inquiry practices independently) based on students' needs and prior knowledge (Baur & Emden, 2020). While beneficial, accessing and adapting resources for differentiated SIS teaching remains time consuming, and is one of the primary barriers to implementing differentiated instruction (Robelee & Whipp, 2021). Hence, teachers appreciated access to SIS teaching material that is ready for classroom use, differentiated for a range of science topics, student abilities and interests, and easily adaptable to their local context.

Collaborative communities of practice, common in education (Lotter et al., 2014), proved particularly important in SIS teaching for bringing together a diversity of topics, experiences and contexts; these networks also help overcome time constraints and address SIS teaching complexity by sharing resources, ideas and pedagogical knowledge (Voogt et al., 2016). Additionally, laboratory technicians emerged as key enablers, contributing to teachers' professional development and supporting practical work (Lewis & Treagust, 2013).

Our participants highlighted the importance of student perspectives when teaching SIS. Students provided valuable insights into interesting real-life contexts, reinforcing the benefit of incorporating student views for better engagement (Conner et al., 2025). Additionally, teachers noted various dispositions, skills and knowledge that students need for SIS learning, illustrating its complexity. Recognising that SIS might be best understood as a competence (Osborne, 2013), its teaching could benefit from a sequential approach of contextualisation (i.e., problem solving in an authentic scientific context), decontextualisation (i.e. explicit reflection), and recontextualisation (i.e., problem solving in another authentic context) (Khan & Krell, 2019).

Interestingly six of the 18 participants in this study recognised professional learning (PL) as an enabler, raising questions about PL's perceived value and availability in SIS teaching. Given PL's importance for supporting change in teacher practice (Thompson et al., 2020), this finding warrants further exploration of teachers' PL experiences in SIS education. Further research opportunities extend from the limited number of participants in this study whereby investigations with a broader demographic of teachers, including those in rural and remote locations, and investigate SIS teaching across primary and senior year levels to deepen our understanding of its influences and potential supporting strategies.

CONCLUSION AND IMPLICATIONS

This study reveals the complexity of SIS teaching and identifies various factors contributing to its challenges. While it is difficult to entirely overcome the inhibitors, a range of strategies was discussed to provide support and guidance for teachers and schools for developing and planning SIS teaching. Teachers require diverse supports and long-term professional learning programs to develop SIS knowledge, varied teaching approaches, and strategies for managing diverse student needs. This study has several implications for education practice. Specific recommendations include:

1. Supporting teachers at their point of need when implementing and planning for SIS.
2. Offering access to adaptable resources that meet individual classroom and school needs.
3. Developing national and state curriculum documents with detailed elaborations, including SIS learning progressions across year levels and diverse real-life contexts.
4. Supplementing curriculum documents with aligned teaching resources that include practical implementation guidance and strategies for incorporating student perspectives.
5. Encouraging schools to facilitate collaborative learning groups within and between schools to enhance SIS teaching resource sharing and development.
6. In terms of professional learning:
    a. Providing opportunities for teachers to develop SIS teaching knowledge and skills, including the creation, evaluation, and modification of SIS teaching resources, observe explicit modelling of and practise teaching SIS (Strat et al., 2023)
    b. Supporting teachers in building networks with colleagues, academics, and local interest groups to share knowledge, resources, experiences and provide real-life contexts for SIS teaching
    c. Introducing peer coaching and/or communities of practice to provide opportunities for teachers to interact, work together and develop ongoing, sustained support when they are planning for and implementing SIS in their teaching

These recommendations will help to support teachers and schools in teaching SIS, which will benefit students' development of scientific literacy.

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APPENDIX A

Qualitative Survey Questions

Background information:

1. Which 7-10-year levels of science are you teaching this year?
2. How many years have you been teaching Year 7-10 Science?
3. Do you have a position of leadership in the science department?
4. Where is your school located?
5. Do you have experience with science inquiry methods in previous study or work?

Science inquiry skills focus:

6. What do you consider as being included in science inquiry? (e.g., student identification of questions or problems)
7. What are your current practices for developing students' inquiry skills?
8. What are your current practices for assessing student inquiry skills?
9. What are your challenges in developing students' inquiry skills?
10. Where do you source your inspiration for developing students' inquiry skills?

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