

When students say “I just couldn’t think” : Challenges in Teaching Skilful Thinking

Bavani Nageswana Row [1], Selvaranee Subramaniam [2], Renuka V. Sathasivam [3]

[1] Department of Mathematics & Science Education,
University of Malaya
bavani_rao@yahoo.com

[2] Department of Mathematics & Science Education,
University of Malaya
drselvaranee@um.edu.my

[3] Department of Mathematics & Science Education,
University of Malaya
renukasivam@um.edu.my

ABSTRACT

This paper discusses challenges encountered by selected Year Four science teachers regarding their knowledge and implementation of skilful thinking (ST) in their classrooms. ST is a complex concept comprising three elements; specific thinking strategies, habits of mind and metacognitive thinking. Due of the complexity of ST, the implementation of teaching of thinking skills in primary science is often overlooked. Subsequently, this has led to students’ low achievements in tasks related to higher order thinking skills (HOTS). The sample of this study consisted of nine novice teachers. Semi-structured teacher interviews and classroom observations were the primary sources of data for this study. The findings revealed that the selected teachers lacked knowledge on ST and therefore were unable to implement and infuse ST elements into their daily classroom practices. In addition, other challenges -- such as classroom management, mixed ability students and lack of resources -- hindered teachers from implementing ST successfully in their classrooms. Implications for science teacher education and in-service professional development are discussed.

Keywords: *primary science; skilful thinking; teachers’ knowledge*

INTRODUCTION

In a Year Four science classroom, the teacher gave a task on classifying objects based on the properties of materials. One group encountered a problem in classifying the scissors. They were unsure whether to classify the scissors as metal or plastic because they see the scissors as whole objects made of both metal and plastic. Instead of providing the answer, the teacher chose to provide a cue for the group to analyze their posed problem. The cue that the teacher provided her students was to look at parts-whole relationship, which is a specific kind of thinking strategy. With this thinking strategy, the students were then able to look at the different parts of a whole object and to classify the scissors with justifications to why the object was made of different materials.

- Teacher: Instead of looking at the scissors as a whole object ... why don't you observe and compare the different parts of the scissors?*
- Student 6: The blade is made from metal ... the holder is plastic....*
- Teacher: Ok ... good ... so ... how can you classify it now?*
- Student 2: Put the "blade of scissors" in [the] metal group ... and [the] "holder of scissors" in [the] plastic group....*

Studies have argued that teachers should explicitly introduce and provide opportunities for students to practice various kinds of thinking strategies (Ben-David & Orion, 2013; King, Goodson, & Rohani, 2012; Zohar, 1999). However, teaching students the various kinds of specific thinking strategies is not enough. Teachers should also be aware that they must develop students' habits of mind and metacognition simultaneously in subject content lessons (Beyer, 2008b; Costa & Kallick, 1996; Swartz, Costa, Beyer, Reagan, & Kallick, 2008). Only when all these three elements are taught simultaneously would students acquire higher order thinking skills (HOTS).

The integrated use of various thinking strategies, exhibition of relevant habits of mind, and the ability to think at metacognitive level is called skilful thinking (Swartz & McGuinness, 2014). Swartz (2008) and McGuinness (1999) claim that teaching ST to students is possible through the 'infusion' approach. To infuse means to explicitly teach students related thinking strategies while simultaneously stimulating them to use those thinking strategies in building subject matter knowledge and understanding (Swartz et al., 2008). For example, in the abovementioned situation, the teacher had explicitly described the mental steps involved in analyzing (through role-modelling) by looking at parts-whole relationships, so that the students would better understand the subject matter, which is the properties of materials. Other thinking strategies that can be employed to analyze science concepts are looking at similarities and differences of science concepts, making inferences, providing reasons and giving justifications. These specific strategies would help students to break down information of scientific observations and try to understand how this information makes sense to them for better understanding of the subject content.

In addition, teachers should also make an effort to develop students' habits of mind. There are sixteen habits of mind (Costa, 1999; Costa & Kallick, 1996, 2005). Habits of mind are often associated with thinking dispositions that reflect good thinking practices (Ritchhart & Perkins, 2008). Questioning and problem posing, being persistent, listening to others, and managing impulsivity are considered habits of mind (Costa, 1999; Costa & Kallick, 1996, 2005). In science education, inquiry learning emphasizes students' ability to ask questions and pose problems to solve scientific investigations (Lombard & Schneider, 2013). Studies on how teachers can develop students' habits of mind and the positive impact that this has on overall student academic performance are gaining great interest (Burgess, 2012; Duckor & Perlstein, 2014; Shu, Goh, & Jusoff Kamaruzaman, 2013).

Furthermore, teaching ST can be accelerated if teachers can provide space and resources for reflective practices (metacognition) (Chatzipanteli, Grammatikopoulos, & Gregoriadis, 2014; Magno, 2010; Topcu & Yilmaz-Tuzun, 2009). Reflective practices (metacognition) are crucial for students to become thoughtful about their learning (Chatzipanteli et al., 2014). This allows students to think about their thinking strategies and how they come to understand scientific concepts. Metacognitive thinking among elementary students not only contributes to their science achievements, but also their critical thinking abilities (Magno, 2010; Topcu & Yilmaz-Tuzun, 2009).

Teachers would also need to translate their knowledge of ST into pedagogical practices. This means teachers should know how to introduce a specific thinking strategy into their everyday lessons; engage

students in selected tasks to practice this thinking strategy; teach students to reflect upon their use of the thinking strategy and show students how to transfer their thinking skill into new contexts (Beyer, 2008b; Reagan, 2008). Zohar (2013) has outlined teachers' knowledge on ST into four categories; knowledge of specific thinking strategies, "such as comparing and contrasting, predicting, and decision making, including procedural knowledge on how each thinking strategy can be performed"; knowledge of various types of thinking that can be blended into various approaches (inquiry learning, problem solving, or critical thinking) for application and development; knowledge of metacognition and use of instructions to teach metacognition where teachers encourage student reflection on specific thinking strategies; and knowledge of other thinking-related facets, such as dispositions and habits of mind. These four categories, termed as "knowledge of elements of thinking" (p. 235), are necessary for teaching ST through the infusion approach.

Beyer (2008b) and Reagan (2008) have asserted that teachers also need to possess knowledge in designing content lessons where instruction goals are focused on teaching ST while simultaneously building students' subject matter understanding. For example, in employing inquiry learning to teach science, teachers ought to have knowledge on "what thinking strategies are involved," as well as "when and how to teach" them (Zohar, 2004). Similarly, teachers must acquire the knowledge of how to develop students' habits of mind and promote metacognitive thinking, so that students would be able to take charge of their own thinking process.

Challenges encountered by teachers in teaching ST

This field of research in ST has indicated a gap between the teachers' knowledge and their actual practices of ST (Alwehaibi, 2012; Aubrey, Ghent, & Kanira, 2012; Beyer, 2008; Colcott, Russell, & Skouteris, 2009; Zohar, 2013; Zohar & Schwartz, 2005). Actual teaching practices show disassociation between what teachers should teach with what actually takes place in classrooms. This is because teachers face challenges which hinder them from productively teaching ST in their lessons. One of the greatest challenges that teachers encounter is insufficient knowledge about ST; this has led to inadequate knowledge on how to infuse ST elements into content lessons. For example, science teachers were found to have inadequate knowledge about metacognition and how to teach reflective practices (metacognitive processes) and so they encounter difficulties in fostering metacognitive teaching in their science lessons (Ben-David & Orion, 2013; Zohar, 1999; Zohar & Barzilai, 2013).

Furthermore, infusing ST simultaneously with teaching of content requires a large amount of time and effort, both time for teaching students and time for conducting professional development programs for teachers on teaching ST (Nilsson, 2009). Similarly, teachers also faced challenges on acquiring knowledge of students' ability in thinking, lack of educative teaching resources, constant changes in educational policies, school context and culture with high visibility of summative examinations, and teachers' beliefs in teaching ST (Barak & Shakhman, 2008; Yen & Halili, 2015; Zohar, 2013). Although some studies have investigated these challenges, there is still plenty of room for further investigation to obtain information, specifically in primary school environments. This study aims at eliciting the various challenges novice teachers encountered in teaching ST in Year Four science classrooms.

METHODOLOGY

The study described in this paper is part of a larger study. In the larger study, the aim was to describe the progression of implementing ST among selected Year Four science teachers. To guide teachers in ST implementation, an instructional support with educative features was prepared. To prepare the instructional support module, a needs analysis was conducted to elicit challenges encountered by these teachers in ST implementation.

Sample Selection

The sample of this study consisted of nine novice Year Four science teachers. The teachers were from public schools in two districts in Negri Sembilan state. Novice teachers (with less than two years' experience) were selected because these teachers were found to encounter greater challenges as compared to their senior counterparts, and may need more assistance in applying what they had learnt during their teacher-

training into real classroom situations (Grossman, Hammerness, & McDonald, 2009). Further, novice teachers in the present study were willing to share their views on teaching ST.

Data Collection

Data were collected while the teachers were teaching the first two units in Year Four science curriculum specifications, which are 'science process skills' and 'life science' units. The nine teachers were interviewed after their lessons. Each interview lasted between thirty minutes to one-and-a-half hours. Interview questions targeted current practices of ST elements (teaching specific thinking strategies, habits of mind and metacognition) in their Year Four science lessons and challenges they encountered in implementing ST. Sample questions included: 'do you infuse ST elements into your teachings, if yes explain how?', 'what challenges do you encounter in implementing ST?' and 'how do you infuse ST elements into your Year Four science lessons?' However, only four of them agreed to their lessons being observed. Each observation lasted one hour. A total of seven observations were carried out. Non-participant observations were conducted and the student-teacher interactions were audiotaped. Details of classroom events were recorded. The lessons were audiotaped to capture teachers' verbal instructions and students' responses pertaining to ST implementation. Observations were made to triangulate data obtained from teachers' interviews and audiotaped lessons.

Data Analysis

The data were analyzed using the constant comparative method, coded and categorized. Emerging categories were collapsed into related themes to answer the research question. For example, codes that describe teachers' challenges found in their interview transcripts were compared with codes from lesson transcripts (audiotaped and transcribed) and observation notes to look for emerging patterns. This triangulation process helped in identifying the appropriate categories and themes.

RESULTS

This study found that the selected teachers lack knowledge in all the three elements of ST, resulting in poor implementation of ST in their current practices. It can also be said that a gap exists between what teachers know about ST and the actual ST implementation in their classrooms. Several challenges were identified as possible causes for the gap between teachers' knowledge of ST and their current practices of ST in Year Four science lessons. It is essential to first look into the teachers' knowledge of ST before understanding how they implement ST in Year Four science.

Teachers' Knowledge of ST

Three types of teacher knowledge emerged from data analysis, which are (i) knowledge of thinking strategies, (ii) knowledge of habits of mind or thinking dispositions (iii) knowledge of metacognition.

(i) Knowledge of various kinds of thinking strategies

Six teachers associated thinking strategies to science process skills, such as classifying, predicting, analyzing or making hypothesis. For example, T3 mentioned that she perceived thinking strategies as science process skills, only more difficult, in which students need to think further.

"Actually...I think thinking strategies are the same as science process skills...but slightly difficult...they need to think out of the box..." (T3, L82, Teacher Interview)

T6 perceived thinking strategies more specifically. She said that thinking strategies involve analyzing skills, such as drawing conclusions to make sense of scientific observations.

"Data collected about photosynthesis ... and what students do with it ... is actually [an] analysis skill ... and for me [the] analysis skill means the student must know what they need to know and what can be concluded from their observation." (T6, L102, Teacher Interview)

Others view thinking strategies as higher order thinking skills, in which students must think forward. For instance, T2, said that apart from merely identifying the gases humans inhale or exhale, if students could extend their thinking to think about the functions of each gas, then the students are said to be engaged in higher order thinking.

"If students are asked to think at [the] higher order, they can think further ... for instance ... we know that we exhale carbon dioxide gas ... but by asking them the use of carbon dioxide gas ... that would mean the students are engaged in higher order thinking skills..." (T2, L72, Teacher Interview)

Although in general, the selected teachers perceived thinking strategies in ST as either higher order level of thinking or science process skills, they could not verbalize how they explicitly teach students the mentioned thinking strategies. Instead, they relate to their students' inability to think at higher level.

"They [the students] have limited skills in thinking. That's why they couldn't think at higher level" (T4, L39, Teacher Interview)

T4 further added that:

"Their [the students] thinking is about what they see, what they hear and what they 'get'...they can't think out of the box ..." (T4, L50, Teacher Interview)

T4 perceived her students' ability in thinking as 'observing using senses'. In her point of view, thinking out of the box means students making sense of what they had observed. Again, T4 could not state how she plays the role as a teacher in teaching her students to use different thinking strategies.

(ii) Knowledge of habits of mind

Within the Year Four science curriculum specifications, the habit of questioning and problem posing about scientific phenomenon should be encouraged among students. The selected teachers do have knowledge of what habits of mind are, but they could not describe clearly how they develop the habit of questioning and problem posing among their students. Three of out of nine teachers define habits of mind as 'motivation to think'. T5 said:

"Thinking requires motivation and effort. The students have no motivation to think. Without effort to think...higher order thinking cannot be acquired. Not all are like that...but I think it [motivation] should be cultivated at early stage, from kindergarten" (T5, L21, Teacher Interview)

T7 had much broader and deeper understanding of habits of mind in thinking. He perceived habits of mind as students' curiosity to ask questions, share views about scientific ideas, work as a team and listen with respect for peers. The description given by T7 was indeed among the habits of mind as stated by Costa (1999).

*"Students **should** have the curiosity to ask questions, to share their views about scientific ideas, to cooperate during hands-on activities and to listen to their peers' opinions as well..."* (T7, L19, Teacher Interview).

The terms 'should' (or "*patutnya*" as translated from the Malay Language), indicate that T7 may possibly had assumed that students were supposed to have these habits naturally, which explains why the selected teachers, in general, could not elaborate on how they develop these habits among their students despite knowing about habits of mind. This is because the teachers perceive habits of mind as innate qualities that should come naturally from students.

Adding to this, the teachers also encounter challenge in developing students' habits of mind. Teaching students with mixed ability to ask questions was seen as a great challenge. According to T8 and T5, low achieving students do not ask questions; on the other hand, high achieving students ask a lot of questions. For example, T8 mentioned that:

"Low achieving students do not ask questions at all, we [teacher] ask, wait and we answer them ourselves, high achieving students ask a lot of questions until we [teacher] have to stop them." (T8, L68 Teacher Interview)

Because of this, the selected teachers believe that only high achievers exhibit habits of mind (as innate ability). This belief perhaps had hindered them from taking further effort to develop the habit of asking questions among low performing students. One rationale for such belief was the norm of questions posed by the low achieving students; T3 asserted that her students do not ask 'good' questions. According to her, good questions are questions that exhibit students' thinking about the subject matter being taught, such as 'why, how, when, when, or what'. T3 also said that questions like "Teacher, can you repeat the answer, please?" or "What are we supposed to do?" are common in her classrooms, which have no direct connections with the subject matter being taught. When questioned about what might have caused the low achieving students to ask such questions, the teachers revealed that their students do not put much effort in thinking or in demonstrating their thinking.

On the contrary, T6 had a different perception about habits of mind. She said that from her experience, students who think at higher level would normally "think alone". It seemed that T6 perceived

thinking strictly as a cognitive process, and cannot be made visible to others. Although, most teachers do have good understanding of habits of mind, however, a few, particularly T6, could not identify student behaviors that indicate habits of mind in thinking.

(iii) Knowledge of metacognition

The selected teachers were interviewed regarding their knowledge about metacognition, the third element in ST. T2, T9 and T1 confirmed that they do not know, nor have they heard of the term 'metacognition'. When the question was re-phrased to whether they promote students to think about their thinking, the teachers confessed that they have not yet undertaken such effort.

"That's difficult, I don't think so my students could think at that level" (T9, L101, Teacher Interview)

"I'm not sure, and I never tried asking them to think about their thinking [metacognition]" (T1, L97, Teacher Interview)

Although a few of them said that the term 'metacognition' sounded familiar, they accepted the reality of not being able to integrate instructions for metacognition into their current teaching practice. On the contrary, T7 claimed that she encourages her students to reflect upon their learning after each lesson, which she believed was metacognitive thinking. T7 defined metacognition as an act of reflecting on what the students had learnt for the day, to countercheck with teaching and learning objectives. For example by asking *"what have we learnt today?"* (T7, L33, Teacher Interview), at the end of each lesson. This lack of knowledge of metacognition might explain why the teachers could not help their students to think about their thinking. For example, T4 said:

"Normally, when my students tell me that they don't know (about a thinking skill such as drawing conclusion or formulating hypothesis)...I would ask them why they didn't know...and they would answer "I just couldn't think" (T4, L36, Teacher Interview)

When asked about how she would help the students to overcome their difficulties in thinking (as described in the abovementioned excerpt), T4 replied 'I don't know how to help them'.

Implementation of ST – actual practices among the selected teachers

Teachers' interview data analysis revealed that they know about habits of mind; however, they lacked knowledge of thinking strategies and metacognition. Observation data analysis revealed the actual practices of ST in their current Year Four science classrooms. It was apparent that because the teachers lacked knowledge of ST, they were unable to apply sound teaching of ST into their daily teachings.

During classroom observations, it was found that when students complete scientific investigations, the selected teachers tend to instruct students to conclude their investigations, rather than explicitly teach them how to analyze their observations to make generalizations.

Teacher	:	<i>Okay, have you completed the table?</i> (Observation table after completing hands-on activity)
Students	:	<i>Yes, teacher</i>
Teacher	:	<i>Okay, now can you write the conclusion in the given space below?</i>
Students	:	<i>Mmmm...yes...no...</i> (Different responses at the same time)
Teacher	:	<i>Okay, never mind</i> (Teacher writes the conclusion on the blackboard, and students copy)
Teacher	:	<i>Okay, read this ...</i> (students read aloud and continued their work) (Audiotaped Lesson, L81, T3)

The excerpt shows that T3 did not allocate specific time to teach her students on how to analyze their scientific observation to draw conclusions. Similar flow of lesson was found repeatedly during other classroom observations.

Teachers' lesson plans also did not clearly state specific planning for role modelling the various kind of thinking strategies in analyzing scientific observations. Students were asked to complete the given observation table and, at the end of investigations, they write their conclusions with teachers' guidance. Next, it was also observed that the teachers paid emphasis on activities that neither develop habits of mind nor promote metacognitive thinking among students. Upon further questioning, the teachers revealed a few other issues which hindered them from implementing ST in their lessons. These include difficulties in conducting small group discussions on any given thinking task. On the contrary, teachers showed preference

for whole-group over small group discussions, despite the students being seated in individual groups. The rationale provided by the teachers to prefer whole-group as compared to small group discussions, was that small group discussions often consume longer time and cause discipline problems (noisy classrooms). With time factor being one of the constraints in teaching ST, the selected teachers claimed that discussing thinking tasks or scientific observations in small groups is not feasible, since this process is time consuming. Furthermore, teachers would re-structure the groups so that each group would have at least one 'capable' student to lead small group discussions.

"Normally, I make sure that each group has one smart student to lead the group discussions" (T4, L22, Teacher Interview)

This was in line with classroom observations, whereby most of the groups were organized in such a way. Each group had one or two active communicators (or from the perception of the teachers, smart students). This is due to their perception about students' ability in higher order thinking skills. Having mixed ability students in the same classroom was seen as major issue for the teachers. Observation data indicate similar finding, whereby teachers with inadequate knowledge of ST were more likely to overlook opportunities in developing students' habits of mind, especially when teaching low achieving students. This confirms their claim during interviews, such as *'ST is not appropriate for such [low achieving] students' because the 'students are not motivated to think'.*

"Its [higher level thinking] is not suitable for low achieving students...they can't even share their views or opinions in classrooms" (T8, L97, Teacher Interview)

"They [students] are not motivated when I ask them to think further...for example, if I ask them why do they think bird[s] migrate from one place to [another]...they just keep quiet" (T7, L65, Teacher Interview)

And thus, this belief influenced their approach in teaching ST. The teachers did not reveal explicit activities to promote students' motivation to think further. Instead, they demote learning outcomes of the lessons to much simpler ones. For example, the anticipated students' learning outcome for the skill of 'data interpretation', is:

1.1.8 Level 6 – Able to give rational explanations by interpolating about objects, events or patterns from observed data (Curriculum Standard for Year Four Science, DA, 4)

Level 6 objectives involve higher level of thinking. However, based on students' ability in thinking, teachers limit their questions and activities to Level 1, which is lower order thinking skill, such as *"Give one explanation from observed data"*. Their presumption about low achieving students' ability in thinking had hindered them from moving forward in helping students to gradually achieve Level 1 to Level 6 learning outcomes.

"For group work, I limit the learning goals and the number of HOTS questions for low achievers." (T1, L52, Teacher Interview)

As for ST implementation in terms of developing students' habits of mind and metacognition, similar findings were observed. For example, at one point of classroom sessions, a group was presenting a discussion on measuring weight.

When one boy suddenly shouted at his group mates, "I told you, its 1500g not 1500kg, but you wouldn't listen". (Observation Data, L23, T4)

T4, who was aware of the situation, responded by asking them to stop arguing and continued with the lesson. In the above situation, T4 could have tried inculcating the habit of listening with empathy in her students, so that the communication between students in groups can be improved.

As stated during interviews, most teachers promote their students to reflect about what they had learnt for the day. The questions by teachers were merely for students to retrieve scientific facts and not about how they had performed certain thinking strategies. For instance,

"When the teacher asked about what did they [students] learn today, only a few responded by stating [a] few examples of objects that absorbs water, but others were busy packing up as it was time for recess" (Observation Data, L89, T2)

This gave no or inadequate time for students to think about their thinking. Similar situations were observed with other teachers. This shows that the selected teachers lack knowledge in teaching students to think at metacognitive levels. Although, T5 along with other teachers claimed to be unaware of

'metacognition', she had shown effort in promoting students' metacognitive thinking in her teaching practice. For example, during one of the observations, T5 was promoting her students to think about why it was difficult for them to give inferences.

Teacher 4: *How many of you still do not know how to give inference[s]? Why is giving inference[s] so hard for you?*

Student 1: *Because we have to give reasons for observations....*

Student 2: *It's difficult to think of reasons....*

(Audiotaped Lesson, L62, T5)

T5 modelled on how to be aware of thinking to her students. She made them name the kind of thinking (inference) they were engaged in and if they found 'inference' was difficult. She continued by instructing them to think of the reasons for the difficulty. In this way, T5 had actually promoted her students to be aware of their thinking. However, classroom observation data did not reveal that other teachers too, model metacognitive thinking among their students as T5 did.

Therefore, it can be said that, in general, the selected teachers lack knowledge of ST and on implementing ST elements in their current teaching practices. Although a few teachers have confirmed to have certain degree of knowledge on ST, they still could not implement ST in their lessons because of several constraints as discussed before.

DISCUSSION AND CONCLUSION

The present study addresses some prominent challenges faced by selected Malaysian Primary Four Science in-service teachers in teaching ST in their science classrooms. In understanding why the selected teachers in this study taught thinking the way they do currently, we obtained vital information illustrating that they encounter several challenges in teaching ST in their science classrooms. Not only do the selected teachers lack knowledge of ST, they also lack the knowledge in implementing ST. Adding to this, having mixed ability students in the same class, time constraints and poor small group discussions were also challenging for the selected teachers.

The findings on the selected teachers' challenge in managing small group discussions with mixed ability students is in line with several other studies. For example, Yen and Halili (2015), in their study on the factors hindering teachers in teaching thinking skills, found that low ability students in thinking have no motivation to think further. In addition, other studies have also shown that teachers believe low achieving students lack the ability to deal with tasks requiring higher level of thinking (Topcu & Yilmaz-Tuzun, 2009; Zohar & Dori, 2003). As a consequence, promoting metacognition among such students, as part of ST, becomes even more challenging. Besides that, the selected teachers lack knowledge in promoting metacognitive thinking among their students. Other studies have also confirmed this finding (Beyer, 2008a; Coffman, 2013; Zohar, 2013). For instance, Coffman (2013) and Zohar (2013) have both argued that pre service and novice in-service teachers were lacking in knowledge on teaching metacognition as part of teaching thinking. Zohar (2013) also claimed that the recent trend indicates an increase in professional development programs for teachers pertaining to metacognition and teaching thinking in general. The selected teachers were found unaware not only in promoting metacognition, but also in explicitly teaching specific thinking strategies and developing habits of mind among students. Colcott et al. (2009) have asserted that teachers should employ specific strategies to make students' thinking visible by developing their habits of mind. This means that teachers with inadequate knowledge have encountered difficulties in teaching specific thinking strategies and developing habits of mind. Beyer (2008a), on the other hand, suggested that teachers need to possess knowledge on how to infuse the three elements of ST into content lessons, not as discrete, but as an integrated approach. Infusing ST into Year Four science lessons as an integrated approach, however, was seen as a challenge because the selected teachers lack knowledge of ST and thus, were unable to implement ST in their daily teachings.

The present study has indicated that the selected teachers' knowledge of ST varies from each other, with different levels of understanding in implementing ST. The gap between the selected teachers' knowledge and implementation can perhaps be reduced by the support of educative materials for teacher-learning to teach ST. Therefore, educative curriculum materials should be designed to address the different

needs of Year Four science novice teachers to support learning to teach ST. It should be noted that curriculum material designers and science teacher educators should consider the identified challenges while designing support for teachers in teaching ST in primary science classrooms. By learning to teach ST and acquiring the knowledge to implement ST, the selected teachers would be able to overcome these challenges.

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