YEAR FOUR NOVICE SCIENCE TEACHERS' PEDAGOGICAL KNOWLEDGE AND PRACTICES IN TEACHING SKILFUL THINKING

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Abstrak: Kajian ini menyiasat pengetahuan pedagogi dan pengajaranguru baharu sekolah rendah dalam konteks pengajaran pemikiran mahir (skilful thinking (ST)). ST ialah proses pemikiran yang melibatkan tiga elemen penting iaitu kemahiran berfikir, tabiat fikir dan metakognisi. Dalam pengajaran ST, pertama sekali, guru perlu mengajar murid pelbagai strategi pemikiran untuk membantu mereka menganalisis maklumat dan idea tentang konsep sains. Kedua, guru perlu membangunkan tabiat fikir murid, contohnya, tabiat bijak menyoal dan mengutarakan masalah untuk dikaji. Ketiga, guru juga perlu mendorong murid membuat refleksi terhadap proses pemikiran mereka. Kajian ini menyiasat pengetahuanp edagogi guru baharu tentang pengajaran elemen ST dan penerapannya dalam proses pengajaran sains Tahun Empat. Pengumpulan data kualitatif seperti temubual separa struktur, pemerhatian kelas, nota lapangan dan analisis dokumen yang berkaitan telah digunakan. Terdapat tiga kumpulan guru muncul berdasarkan pengetahuan pedagogi dalam pengajaran ST. Dapatan kajian menunjukkan bahawa terdapat variasi dalam pengetahuan guru tentang ST dan pengajaran ST. Malangnya, kekurangan dalam pengetahuan pedagogi guru baharu ini telah menghindarkan murid daripada berfikir secara mahir dalam proses pengajaran dan pembelajaran sains. Cadangan telah diketengahkan untuk meningkatkan kualiti pengajaran ST dalam kalangan guru sains sekolah rendah.

Kata Kunci: *pemikiran mahir, pengetahuan pedagogi, sains sekolah rendah*

INTRODUCTION

One of the goals of primary science education is to instil thinking skills. Thus, it is crucial for teachers in elementary science classrooms to teach young students how to think skilfully, and subsequently using these skills, students may come to understand science concepts more meaningfully. The concept of skilful thinking (ST) refers to a collaborative and intertwining process consisting of three elements: knowing about different kinds of thinking strategies, habits of mind, and metacognition. (Swartz, Costa, Beyer, Reagan, & Kallick, 2008). ST should be taught as an independent goal but simultaneously with the subject matter content.According to Swartz *et al*. (2008),various thinking strategies, namely comparing and contrasting, sequencing, classifying, and part-whole-relationships should be highlighted and taught simultaneously with the content matter. The use of these thinking strategies enables students to analyse information they have gathered, thus facilitating subject matter understanding. Whilst teaching these strategies, teachers should also incorporate the development of students' habits of mind and metacognitive thinking (Beyer, 1987; 1998; 2008). Habits of mind describe students' thinkingand is often recognized as students' thinking-in-action. Examples of habits of mindare questioning and problem posing, as well as being persistent.These habits of mind enable students to learn how to ask different types of questions and also when they are faced with difficulties, how they must to these situations by being persistent.Teachers should also encourage students to reflect about their thinking and assist them in developing their metacognitive skills. Therefore it is clear to see that if teachers teach ST in their daily classrooms, students would be able to develop order thinking skills (HOTS) more effectively (Miri, David, & Uri, 2007).

Since ST is a copious concept, studies have shown that primary science teachers find it difficult to introduce ST into their lessons(Beyer, 2008; Murphy, Bianchi, McCullagh, & Kerr, 2013; Zohar & Schwartzer, 2005). This situation may be more challenging for novice teachers(Sothayapetch, Lavonen, & Juuti, 2013). Thus, this paper focuses on

Year Four novice science teachers' pedagogical knowledge in teaching ST. The findings of this paper are part of a larger study where we developed a heuristics instructional support for teaching ST. This paper discusses the needs analysis portion of the original study. We asked the following question: What is Year Four novice science teachers' pedagogical knowledge in teaching ST?

What is Pedagogical Knowledge in teaching ST?

We used Shulman's categorization of teachers' knowledge- conceptual, procedural and curricular knowledge to classify teachers' knowledge on ST. In Shulman's model, conceptual knowledge refers to teachers' understanding of the subject matter, procedural knowledge is the knowledge on the series of steps taken to teach a particular subject matter and curricular knowledge refers to knowing when to use a certain strategy to teach a topic within a specified curriculum(Shulman, 1986;1987).

In this study, teachers'pedagogical knowledge in teaching ST refers to two subcomponents: knowledge of ST and knowledge of pedagogies in teaching ST. Knowledge of ST refers to teachers' conceptual understanding of ST. This is parallel to Shulman's conceptual knowledge. In contrast, knowledge of pedagogies in teaching ST, refers to both procedural and curricular knowledge on how and when to apply specific pedagogies in teaching ST. Knowledge of ST implies what teachers know and understand about the three ST elements-specific thinking strategies, habits of mind and metacognition. However, studies have shown a lacking of teachers knowledge of ST (Ben-David & Orion, 2013; Zohar, 1999), where teachersdo not know that ST involves three elements or how thinking skills are different from ST.

In terms of knowledge of pedagogies in teaching ST, it refers to the knowledge on how and when to teach ST in content lessons. For instance, in teaching about the Solar System, which is a topic in the Malaysian Year Four science curriculum, the key learning outcome is to analyze knowledge about the Solar System. This can be done by modelling specific thinking strategies in analysing, such as to compare and contrast the planets' characteristics and therefore infer the sequence of planets. Hence, teachers should firstly be aware of such specific thinking strategies involved in analysing and understand that these are the analyzing strategies that students would need to acquire in order to better understand the Solar System. Apart from that, teachers should also encourage students to develop the habits of mind, one of which is questioning to gain more information. When students face barriers in their thinking, teachers should also encourage them to be persistent by posing different sets of questions. Thirdly, teachers need to promote metacognitive thinking among students by helping them reflect upon their own thinking strategies. For example, teachers could invite students to discuss how they had performed the comparing, contrasting, and sequencing of the planets, as well as how they could improve their thinking strategies. These are the three elements of ST that teachers need to teach explicitly during lessons (Barak & Shakhman, 2008a; Beyer, 1998). Figure 1 shows the graphic interpretation of the categorization of teachers' knowledge in teaching ST.

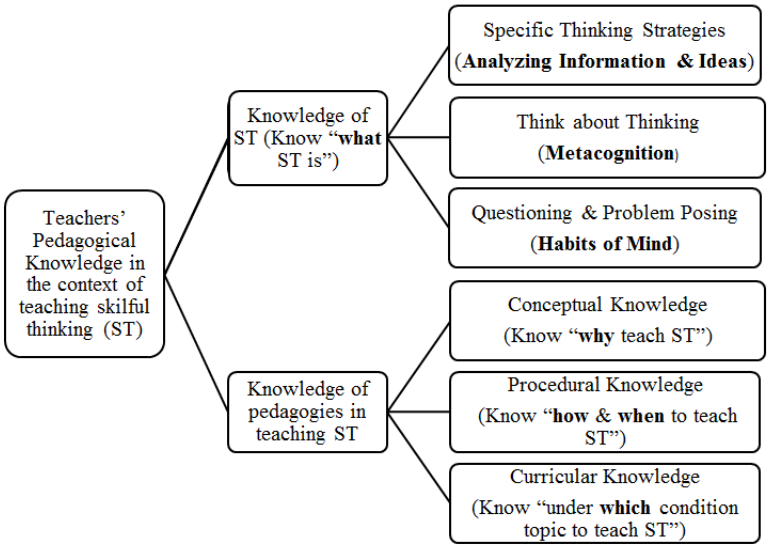

Figure 1: A graphic interpretation of categorization of teachers' knowledge in teaching ST [Based on Shulman, 1987, Swartz *et. al*., 2008 and Zohar, 2004]

Why do this study?

A number of studies have investigated teachers' pedagogical knowledge of ST and recommended more research to be done on this aspect (Coffman, 2013; DiBiase & McDonald, 2015; Wilson & Bai, 2010; Zohar & Schwartzer, 2005; Zohar, 2004). However, many of these studies have only looked into either one element of ST and examining this element inisolation (Zohar, 2004). For example, Zohar (2005) investigated teachers' pedagogical knowledge in teaching ST, focusing on the instructions for metacognition.Subsequently, other studies that focused on only aspect of ST such as assessing students' habits of mind (Duckor & Perlstein, 2014), teaching habits of mind (Goodell, 2014) and numerous studies on developing a particular thinking skills (Hugerat, 2014; Mutlu & Temiz, 2013).In terms of envisioning future teaching strategies, however, all studies were vocal in advocating a holistic teaching of ST. Swartz et al. (2008) and Beyer (2008) argued that teachers' pedagogical knowledge in teaching ST should include the knowledge of pedagogies in teaching all three aforementioned elements as an integrated model of teaching HOTS. Similar arguments were raised by several other scholars, affirming that teachers should clearly understand the concept of ST as well as how, why, and when to integrate all ST elements simultaneously into science content lessons (Barak & Shakhman, 2008a, 2008b; Costa & Kallick, 1996; Miri, David, & Uri, 2007; Murphy, Bianchi, McCullagh, & Kerr, 2013).Teachers need to be aware of and familiar with the various elements of ST. If this is absent, Yen and Halili (2005) have assertedthat teachers may view thinking skills as not teachable. And this perception, may cause teachers to restrict opportunities to infuse ST in their science lessons.

Earlier studies have given central attention to teachers' lack of knowledge of instructions for developing students' ST (McGuinness, 1999; Walsh, Murphy, & Dunbar, 2007; Zohar, 1999; Zohar & Schwartzer, 2005). Zohar (1999) carried out a qualitative study and found that in-service science teachers' knowledge in teaching metacognition was at an unsatisfactory level. In a much recent study, Zohar (2013) also found that teachers had insufficient knowledge of how to plan instructions for reasonable and coherent flow of lessons promoting ST. Similarly, Barak and Shakman (2008a) have claimed that teachers have problems with the whole concept of teaching thinking skills, thus impeding active implementation of ST in primary science. In general, these studies indicate that primary science teachers urgently need knowledge upgrade regarding teaching of ST.

Therefore, this study investigates Year Four novice science teachers' pedagogical knowledge in teaching ST. We chose novice teachers because studies have shown that novice teachers need support to understand the importance of practicing difficult principles and to acquire the knowledge on how to apply them, like teaching ST (Beyer & Davis ;2009).

METHODOLOGY

This study was conducted in Negeri Sembilan, a state in Malaysia. Nine co-educational national primary public schools were involved in this study.

Sample

In our study, we defined novice teachers as teachers who have less than two years of experience in Year Four science. We chose novice teachers because in our original study, we planned to prepare a heuristics instructional module to support teachers in implementing ST. The participating teachers consist of two male and seven female teachers. Permission was obtained from the school principals and consent letters from the teachers.

Data collection

Each teacher was interviewed once and each session lasted for thirty to forty minutes. The interview protocol was semi-structured and consist of two sections. The first section was questions pertaining to teachers' knowledge of ST and the second on teachers' knowledge of pedagogies in teaching ST. Sample of questions included, "*Do you know about ST? If yes, what can you tell me about ST?*' and "*How do you teach ST in your science lessons?*" Document analysis was also conducted on the Year Four science specifications to look for anticipated learning outcomes for the topics the teachers were teaching. In addition, to enhance the quality of this study, we also conducted classroom observations. Classroom observations were conducted to see if teachers who verbalize what they know about ST, actually carried them out in their classrooms.As only six teachers agreed for their lessons to be observed, we managed to conduct a one hour lesson for each teacher. The classroom observations were done to see how these teachers practice ST in their classrooms.

Data Analysis

The data analysis process comprised three stages. Firstly, the preparation of raw data for analysis. The interview sessions were transcribed into verbatim.The transcripts were send for member-checking. Each interview transcript was read twice, to identify segments of texts that best describe shared characteristic of a theme. In the matrix developed for each teacher, there was pre-determine themes: 'teaching thinking strategies', 'habits of mind' and 'metacognition'. For example, in the interview with Julie(pseudo name given to one of the participant), we identified a segment that reads '*I haven't start teaching thinking skills…I hope I can get help on how to teach"*. We tagged this segment to a code named as 'teaching thinking strategies'. In another transcript, we found segments that can be coded as 'habits of mind'. For example "*students do not take the effort to think, so how to teach them thinking skills?*" This was coded as 'habits of mind'. This process was repeated for the observation data. For instance, we observed that Julie was prompting her students to justify their observations, by asking "*You said that the volume of water has decreased, why you said so?*" She was trying to encourage her students to think of reasons as to why they said that the volume of the water has decreased. This observation segment was assigned to 'teaching thinking strategies'. Similar method was carried out for the remaining participants. Once the matrix was done, we organised a peer-review session where through discussions and reviewing of data we manage to elicit three groups of teachers. The three groups were called Group A, Group B and Group C. Group A teachers could not verbalize their understanding of ST and thus were not able to practice these skills in the classrooms. Group B teachers were more knowledgeable about ST; however, their practices did not match their knowledge. Group C teachers claimed that they did not know about ST, however, did exhibit certain aspects of ST in their practices.

FINDINGS

Three groups, where teachers within each group, showed very similar knowledge and practices of ST emerged from the findings of this study. We chose one teacher as a representative to describe the findings for each group. Thus, Lydia, Aisha and Sheela represent Group A, B and C respectively. This study has found that there was a variation in terms of the noviceYear Four science teachers'pedagogical knowledge in teaching ST. We decided to describe only the teachers who contributed rich data, as the representative for each group.

Group A – "I don't know about ST, so I don't teach ST"

Lydia, along with four other teachers was categorized into Group A. Lydia claimed that she knows what higher order thinking skills are, but not what ST is. She explained that the learning outcomes as stipulated by the syallbus requires Year 4 teachers to inculcate higher order thinking skills, such as analyzing, synthesizing, and creating. In fact, she had written in her lesson pelan record book that the learning outcome for the lesson was to '*To analyse knowledge about the Solar System*'.

When Lydia was asked how she would teach the specific thinking skills strategies in analysing knowledge about the Solar System, Lydia was not able to verbalize how she would do so. During classroom observation, Lydia taught the topic on classfying materials that absorb water. Her students weretesting a given list of objects and recorded their observations in a readily-prepared table. At the end of the activity, Lydia posed questions like '*Can you tell me which object can absorb water*?" and concluded that sponge, paper and handkerchief absorb water. We could not observe any evidences to show Lydia modelling how students could make generalizations of scientific observations using different kinds of specific strategies. For example, compare and contrast the materials the objects were made from or to provide inferences on why these objects do/do not absorb water. She could have asked her students to compare and contrast the common features of the objects, before classifying the objects into two different groups, so that the students would be able to justify their classifications. Therefore, we deduced that Lydia could not explicitly teach her students how to analyze their observations using specific thinking strategies such as comparing and contrasting, or classification based on common characteristics. Lydia also had confirmed lack of knowledge in the other two elements of ST- habits of mind and metacognitive thinking. She said that:

> "*I have never heard of it [habits of mind and metacognition] before*"
>
> Lydia, Teacher Interview

Her observation data was parallel with her statement. We had observed few opportunities in which Lydia could have tried to develop students' habits of mind. Instead, she did not try to engage her students in metacognitive thinking. For example, when one of her students, classified paper into objects that does not absorb water, Lydia asked the student to correct his observation record. She did not try to ask for possible reasons as to why the student classified paper into the wrong group. She could have facilitated her student to evaluate hisclassifying strategies, so that he can be guided

to improve himself. Based on our interview and classroom observation, we categorized Lydia into Group A because she had claimed that she does not know about ST, which explains her lack of practices that could demonstrate knowledge of pedagogies in teaching ST.

Group B –"I know about ST but I don't know how to teach ST"

Aisha had some conceptual understanding of ST and the importance of teaching ST in primary science lessons. She explained that scientific processes are examples of higher order thinking skills, which students need to acquire in analysing knowledge about science concepts.

> *"It's about what students can learn from the data analysis…for me, analysis means they know what they need to look for and what they can learn from it…and make generalizations from their observations"…*Aisha, Teacher Interview

Aisha believed that science process skills,such as giving inferences or providing reasons for scientific observations that involve different strategies, are actually examples of higher level thinking. Aisha said, *"It's actually the same as science process skills"*. She also shared her thoughts about students' habits of mind in thinking. Aisha explained that habits of mind refers to students' own initiative to think further and that it would be difficult to teach if students do not take the extra effort to think. She explained:

> *"Students must take effort to think further, it's difficult to teach higher order thinking skills, if they are lazy to think"* Aisha, Teacher Interview

Aisha further added:

> *'I ask many questions, but they don't respond to my questions and I'll have to answer the questions myself…."* Aisha, Teacher Interview

Although Aisha had some ideas about thinking strategies and habits of mind, however she could not verbalize what she knows about metacognition. Aisha said that the term 'metacognition' sounded familiar to her, but could not recall its' meaning.

> "*I remember learning about metacognition during my teacher-training program, but I couldn't recall what it is actually...I've forgotten….*"
>
> Aisha, Teacher Interview

We observed her lesson to see if she could integrate her knowledge of thinking strategies and habits of mind into her science lesson, since she had verbalized earlier. We found that her classroom observation did not reveal significant evidence to show that she transferred what she knows about ST into her teaching practices. In the classroom, her students were asked to build models from recyclable materials, to demonstrate the human breathing mechanism. A few groupsdid not get their models to function properly. Aisha checked the models and corrected on their mistakes. She then continued her class by giving them worksheets. We found that Aisha seemed to have missed the opportunity to engage her students in thinking about their malfunctioned models. She could have asked them to question what went wrong with their models and to recommend solutions, instead of her identifying their mistakes and straight away provide solutions. Aisha should have given them the opportunity to compare, contrast with other models, or recognize possible reasons for their faulty models. Such application would had justified her knowledge of ST.

We questioned her as to why she did not apply what she had claimed to know about ST. Aisha revealed that there were several challenges such as time constraint and excessive workload, which hindered her from explicitly teachingthe different kinds of thinking strategies.Due to such challenges, Aisha argued that she could not plan to explicitly teach ST. Despite the challenges she had outlined, she also claimed that she does not understand how exactly to teach ST because she found it difficult to integrate into her lessons.

> "*"Teaching students how to analyze? Mmmm…It's difficult…actually, I still don't understand…even my friends too…*" Aisha, Teacher Interview

Although Aisha, could recall and explain briefly on the first two elements of ST, she could not demonstrate related knowledge of pedagogies in teaching ST in her lesson. This might indicate that Aisha may have some knowledge of ST, yet still needs help for sound practices in teaching ST in her lessons.

Group C – "I didn't know that I knew about ST"

Sheela claimed that she does not know about ST, particularly the habits of mind and metacognition. As such, her explanations about St were superficial and accurate. However as when we observed her lesson, we found that she was trying to promote metacognitive thinking. Sheela was not aware that she was actually trying to promote ST, even though at a superficial level.

Teacher Sheela: *So, what would happen if you are not able to give an inference?....You would not be able to make conclusions…right?*
Audiotaped Lesson Transcript

The excerpt shows that, although Sheela eventually answered her own question, she indeed tried to provide a cue to promote her students to think about how and why they should give inferences. She gave them hints on what would happen if they did not persist in improving the way theymake inferences.However, she could not verbalise that she was actually promoting her students to think about their thinking (metacognitive thinking). It can be said that although Sheela has the potential to promote metacognitive thinking in her science lessons, she still needs further guidance in sharpening her pedagogies, particularly on how to model thinking about ones' own thinking. When questioned about the rationale for her attempt, Sheela mentioned that she wanted her students to understand the skill of 'giving inferences' because it was a difficult skill to acquire.

> *"I want them to learn to give inference….normally that's the most difficult skill for the students…"* Sheela, Teacher Interview.

In constrast to her statement, we found that her prompts were more than merely inferencing. We observed that Sheela had actually prompted her students to perform specific thinking strategies in analysing their knowledge on the human breathing mechanism. She had offered a ground for her students to compare and contrast the chest movements at two different situations.

> *"How do you know if someone is alive or dead? Will you look for his/her chest movement?" Observation Data*

> *"How about if you're not allowed to touch him, how would you know if he's still breathing?"Observation Data*

Subsequently, Sheela had also prompted her students to perform another kind of thinking strategy- predicting.

> *"What will happen to our lungs if there's no air?Why?"Observation Data*

However, according to Sheela, these were the prompts she had identified as the prompts for inferencing. If Sheela had more knowledge on the differences between the different kinds of thinking strategies involved in analyzing scientific information, then, perhaps she would have been more conscious of what she was doing. This might have supported her in improving her practices in teaching ST.

DISCUSSION AND CONCLUSION

The present study had investigated novice Year Four scienceteachers' pedagogical knowledge and practices of ST in Year Four Science. From the teacher interview data, we found that most teachersperceived thinking at higher level for their students to be an innate ability -- and therefore not teachable. Similar findings was also reported by Yen and Halili (2015). Yen and Halili (2015) found that selected Malaysian Science and Mathematics teachers viewed thinking at higher level was only for high performing students. They reasoned that it was difficult to teach thinking skills to low ability students because they may not be able to think further (Coffman, 2013; Madhuri, Kantamreddi, & Prakash Goteti, 2012; Rajendran, 2008; Zohar, 2013).

Most of the teachers in this study discounted the importance of developing habits of mind and metacognition while teaching students to think at higher levels.Although most of them were aware of the rationale for teaching analytical skills in science lessons, they could not associate with the rationale of developing students' habits of mind, mainly with regard to asking questions and posing problems. For example, the teacher-student interactions did not reveal evidences to show that the teachers explicitly teach students to pose problems and ask questions or to think at metacognitive levels.These findings werealike to previous studies investigating teachers' pedagogies in promoting habits of mind and metacognition (Barak & Shakhman, 2008a).

For successful implementation of inquiry learning in elementary science, teachers must encourage students to ask questions, pose problems, and seek scientific explanations (DiBiase & McDonald, 2015). This can be achieved by creating opportunities for students to ask questions and share their thoughts comfortably without the fear of rejection (Costa, 1999). It is important to instil the idea in young learners that science is best learnt by asking questions and seeking explanations. This entails students understanding the nature of questions themselves, such as being conscious of the types of questions that can be used to analyze scientific information or understand science concepts. Needless to say, it is important for teachers at the elementary level to teach students to ask "how and why" questions. Other studies have also confirmed this stand, arguing that teachers firstly need to possess pedagogies of encouraging students to ask and answer their own questions, and secondly, pedagogies of promoting students to evaluate the context of their questions (Costa, 1999; Sen, 2013).

Similar argument was raised by Swartz *et. al* (2008) and Beyer (2008), suggested that teachers should teach students how to think using different thinking strategies, by modelling each thinking strategy. For example, by explicitly describing the mental steps needed to be taken while performing a specific thinking strategy, such as comparing, inferring, providing justifications, or looking for connections among information. Teaching students *how to think* as a means to gain science knowledge is far more important than merely imparting science knowledge (Beyer, 2008). An extension of this process is to promote learners' metacognitive ability (Swartz et al., 2008). At a point where learners are able to perform various kinds of thinking strategies, they need to know why they perform those thinking strategies, how to and when to apply them in the future (Ben-David & Orion, 2013; Swartz et al., 2008; Zohar & Barzilai, 2013).

Although our sample is small, we believe that these novice teachers need to upgrade their knowledge in ST and their knowledge of pedagogies in teaching ST, only then teachers are able to practice ST in their classrooms. This is due to the fact that the teachers seem to have limited knowledge about ST and most importantly, on how to infuse ST into their science lessons.This lack of knowledge and practices of ST may have adverse effects on low performing students because teaching thinking is possible if teachers are equip with relevant knowledge and skill (Coffman, 2013; Zohar, 2013; Zohar & Schwartzer, 2005).

It would not be appropriate to generalize the findings of this study, as the unit of analysis was only nine novice teachers.Even so, our findingsindicate that teacher educators and professional development training providers may find it worthwhile to consider novice teachers' levels of pedagogical knowledge in teaching ST while designing support for them as this have effect on their practices.

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