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Metacognition Enhancing Strategies in Science Classrooms: Science Teachers' Practices

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Abstract

In this study, we aimed to determine metacognition strategies that science teachers use in science lessons and activities they can perform within the scope of these strategies. We used an instrumental qualitative case study design. Research data were collected from science teachers working in public schools during the 2018–2019 academic year. The findings revealed that science teachers' definitions of the metacognition concept are developed and compatible with the definitions in the literature. We also found that science teachers use most of the metacognition-enhancing strategies proposed in the literature. The results showed that science teachers generally do plan before the lesson, encourage their students to ask original questions and think for themselves, motivate their students to evaluate their learning experiences based on multiple criteria, encourage their students to empathize and be motivated, help their students to cope with the difficulties, create environments where students can reflect their ideas, try to make students aware of their behaviors, ask their students to explain their statements, perform role-playing and drama activities, and try to be a role model for their students. However, science teachers use journal-keeping strategies less than other strategies. We believe that the research can make a significant contribution to the literature and serve as a substantial resource especially for young teachers to gain a solid background in metacognition and how it can be incorporated into one's teaching practice.

Keywords: Metacognition, metacognition enhancing strategies, science teachers

Introduction

Thinking is not a one-dimensional concept; rather, it consists of many dimensions. Marzano et al (1988) list the following dimensions of thinking: critical and creative thinking, macro-thinking, micro-thinking, content area knowledge, and metacognition. One of these dimensions, metacognition, which is defined as learning to learn, is very important for students to improve their thinking skills (Lukitasari et al., 2019). Flavell (1978) first introduced the concept of metacognition and defined it as the highest level of thinking skills. Costa (1984) defined metacognition as being aware of whether one knows and being aware of the mental methods used in problem-solving. Moreover, Papleontiou-Louca (2003) defined metacognition as controlling and realizing one's emotions and motivation.

Metacognition is a high-level mental skill that is effective in realizing the educational goals of students and increases the effectiveness of teaching activities, occurs at an early age, and can develop until the end of adolescence (Benton, 2014; Brown, 1987). Metacognition stimulates awareness about instructional decisions and the reasons behind them in the classroom environment by defining, reflecting, and assessing (Griffith et al., 2016). Research in the literature indicates that learners will become more skillful in the utilization of learning strategies if they learn more about the nature of strategies and grasp when a specific approach should be used (Boström & Lassen, 2006; Oxford, 1989). Furthermore, the development of students' metacognitive skills will foster their learning outcomes (Davidowitz & Rollnick, 2003; Thomas & McRobbie, 2001), problem-solving skills (Sperling et al., 2002), thinking skills (Chen, 2020; Orion & Kali, 2005; Preus, 2012), critical thinking (Akama, 2006; Ku & Ho, 2010; Magno, 2010) and self-efficacy (Muwonge et al., 2017; Şen & Yılmaz, 2016).

As the significance of these competencies in education is known well, the importance of students' having metacognitive skills is apparent. Another fact that becomes visible at this point is that for students to have these skills, teachers who educate them should also have developed metacognition skills (Jones et al., 1995). Thus, teachers need certain competencies to train students in metacognition skills. These competencies include having an attitude that will increase students' metacognition (Goos et al., 2002), helping students to build their learning processes (Williamson, 1996), giving feedback that will enable students to control their learning processes (Pintrich, 2002; Toney, 2000), allowing students to practice and encouraging them (Gourgey, 2001), knowing which strategies are effective in the development of students' metacognition and how to use them within the curriculum (Kiewra, 2002; Veenman et al., 2006), and organizing learning environments (Blakey & Spence, 1990; Hartman, 2002).

Purpose of the Study and Research Questions

Theoretical and empirical studies highlight the importance of teachers' competencies to develop their students' metacognitive skills. Therefore, we believe that determining metacognition-enhancing strategies used by science teachers and the activities they perform while using these strategies is significant. In this way, it will become possible to understand how science teachers create a learning environment that enables students to explore the content as well as have a meaningful experience in the classroom. In addition, the results of the examination can serve as a substantial resource for

especially young teachers to gain a solid background in metacognition and how it can be incorporated into one's teaching practice.

The purpose of the study was to determine metacognition strategies that science teachers use in science lessons and activities they can perform within the scope of these strategies.

The following research questions guided this study:

- How do science teachers define metacognition?
- How do science teachers use metacognition-enhancing strategies in their classrooms?

Literature Review

Although metacognition has different definitions, it has two fundamental dimensions: metacognitive awareness and metacognitive strategies. Metacognitive awareness refers to what learners know about their learning, whereas metacognitive strategies refer to learners' regulation and management of their learning (Schraw et al., 2006). When we examined the literature, we discovered that there are different approaches and instruction types to enhance individuals' metacognition (Alderman et al., 1992; Blakey & Spence, 1990; Chen, 2020; Costa, 1984; Oxford, 1990; Preus, 2012). For example, Oxford (1990) discussed metacognition-enhancing strategies in three groups, whereas Costa (1984) proposed an approach consisting of 12 strategies. We carried out this study based on these 12 strategies suggested by Costa (1984).

Costa's (1984) 12 metacognition-enhancing strategies are as follows: planning, generating questions, choosing consciously, evaluating with multiple criteria, taking credit, outlawing "I can't," reflecting students' ideas, labeling student behaviors, clarifying students' terminology, role-playing, journal keeping, and modeling. In the "planning" strategy, teachers inform students about activities and organize their learning environment. In the "generating questions" strategy, teachers encourage students to ask questions before and during lessons. Teachers who use the "choosing consciously" strategy enable their students to evaluate their decisions and also provide feedback that will help and judge students. Teachers who use the "evaluating with multiple criteria" strategy can improve students' metacognition by categorizing the activities according to two or more criteria that will cause students to think. Thus, teachers can evaluate the pros and cons of the activities, and if students find them useful or difficult, they like or dislike them. In the "taking credit" strategy, teachers make students aware of their strengths and encourage them to get feedback from their peers. The teachers who use the "outlawing I can't" strategy help students eliminate behaviors such as "I cannot do" and "I do not know what to do" in the classroom. For this purpose, they direct their students on how to use their knowledge and skills. In the strategy of "reflecting students' ideas," teachers enable students to listen to the thoughts of their peers. Teachers who use the "labeling student behaviors" strategy make their students aware of the strategies they use and explain what behaviors they will exhibit in the activities. In the strategy of "clarifying student terminology," teachers ask students to explain the words and expressions that are not being understood by others. Teachers who use the "role-playing" strategy ask their students to put themselves in someone else's shoes and act like them. Teachers who

use the "journal keeping" strategy enable students to keep journals to convey their experiences and thoughts. Finally, in the "modeling" strategy, teachers can ask their students to evaluate their activities and explain their strengths and weaknesses to students (Costa, 1984; Costa & Lowery, 1989).

Metacognition theory has significant potential to help teachers create a flexible and creative learning environment in their classrooms (Borkowski & Muthukrishna, 1992). Based on the results of the relevant research (Davidowitz & Rollnick, 2003; Paris & Winograd, 1990; Thomas & McRobbie, 2001), one can observe that students' learning outcomes can improve when metacognition development strategies are used effectively in the classroom. In addition, metacognition has an important role in programs aiming to develop higher-level thinking skills (Chen, 2020; Swartz, 2003; Zohar, 1999). Also, there is a positive and significant relationship between metacognition and problem-solving skills (Bakioğlu et al., 2015; Kaplan et al., 2016). Furthermore, studies have revealed that metacognition enhancement programs develop participants' problem-solving skills (Safari & Meskini, 2016; Serin, 2014).

Method

We used an instrumental qualitative case study. In instrumental case studies, researchers focus on certain cases to gain a general understanding and to get insight into the research question (Creswell & Poth, 2016). In this context, since this study aims to determine metacognition strategies science teachers use in science classrooms, we preferred the instrumental cased study model.

Participants

In this study, we determined the participants using the criterion sampling method, which is a type of purposeful sampling (Creswell, 2012). In this context, we chose teachers who were continuing their postgraduate studies since studies show that postgraduate students exhibit more metacognitive maturity and metacognitive techniques (Bria & Mbato, 2019). Moreover, as a result of activities such as writing articles, making presentations, and reflecting in graduate education, teachers in postgraduate education are more likely to use metacognition-enhancing strategies while they are teaching. For ethical reasons, participants were given the pseudonyms of Hale, Aras, Ali, Naz, Beril, and Su. Table 1 shows the demographic information of the participants.

Table 1.

Demographic Information of the Participants

	Participants					
	Aras	**Hale**	**Naz**	**Beril**	**Su**	**Ali**
Gender	Male	Female	Female	Female	Female	Male

City	Hatay	Kayseri	Kayseri	Kayseri	Kayseri	Niğde
Graduation	Education Faculty	Faculty of Sciences	Education Faculty	Education Faculty	Education Faculty	Education Faculty
Age	25	52	38	29	33	30
Seniority	1	28	6	5	7	5

Data Collection

We used a semi-structured interview as the data collection tool. One of the most effective data collection tools used in qualitative research is the interview (Briggs, 1986; Merriam, 2013; Patton, 2002). For the interviews, we prepared a semi-structured interview form based on our literature review on the subject (e.g., Costa, 1984; Costa & Lowery, 1989). Two science educators who do research on science education and three science teachers who teach science in middle schools checked the interview form in terms of content and intelligibility. The first researcher and participants scheduled interviews. The interviews started with demographic questions. During the interview process, we used a voice recorder with permission from the participants. Interviews lasted for approximately 20–30 minutes. After the interview was held, the audio recordings of the participants were played and reaffirmed. Finally, we transcribed interview sessions and started data analysis. Also, we followed ethical principles and rules during the planning, data collection, analysis, and reporting of the research.

Data Analysis

Data analysis comprised several cycles of coding resulting in the identification of meaningful themes (Creswell, 2009). In the interview, we first asked the participants whether they used each metacognition enhancing strategy and then asked how and why they used it. We employed intercoder agreement (Creswell, 2009) to identify and agree on the main themes. Additionally, we used member checks and trustworthiness validation criteria typical for qualitative studies (Creswell, 2009; Patton, 2002).

Description of the Findings

The thematic analysis allowed us to address the following: definition of metacognition; “Planning” strategy; “Question Generating” strategy; “Choosing Consciously” strategy; “Taking Credit” strategy; “Outlawing I Can’t” strategy; “Reflecting Students’ Ideas” strategy; “Labeling Student Behaviors” strategy; “Clarifying Students’ Terminology” strategy; “Role Playing” strategy; “Journal Keeping” strategy; and “Modeling” strategy.

Definition of Metacognition

One of our goals was to examine how teachers define the concept of metacognition. Findings regarding the definition of metacognition are presented in Table 2.

Table 2.

Codes Related to the Definition of Metacognition

Questions	Codes	Participants					
		Hale	Aras	Ali	Naz	Beril	Su
How would you define the concept of metacognition?	Awareness of one's knowledge		X		X		X
	Knowing how you learn			X	X	X	
	Self-regulation			X			
	Being aware of what you think		X			X	
	Be aware of how to reach results		X			X	
	Knowing your skills	X					X
	Being aware of self-weaknesses and strengths	X		X			

Table 2 demonstrates that the participants defined metacognition from different perspectives. For example, Ali defined metacognition from three different perspectives. According to Ali, metacognition is about knowing how the person learns, organizing self in the learning process, and being aware of self-weaknesses and strengths. Ali explained his definition as follows:

> *I think metacognition is when students realize how they learn. For example, s/he knows how s/he learns, realizes his/her weaknesses and strengths, and regulates self in this regard.*

Similarly, Aras defined metacognition in three different ways and expressed it as being aware of one's knowledge, thinking, and how to achieve the results. Hale defined it as skills of knowing his /her abilities and being aware of his/her weaknesses and strengths. Another participant, Naz, defined metacognition as knowing how one learns.

"Planning" Strategy

Planning is an important component of instructional practices. Table 3 shows how participants described their planning strategies.

Table 3.

Codes Related to the "Planning" Strategy

Questions	Codes	Participants					
		Hale	**Aras**	**Ali**	**Naz**	**Beril**	**Su**
Do you plan before your classes?	Yes	X	**X**	X	X	X	
	Partially						X
	No						
What do you consider when planning?	Objectives	X		X			
	Student level	X				X	
	Learning environment	X	X		X	X	X
	Time					X	X
	Student motivation		X		X		
	Physical and psychological conditions of the student		X				X
	Teaching material			X	X		

To the question about whether teachers plan before classes, Su said, "Mostly yes," Aras said, "I do not plan before class," and others stated that they do plan. Within the scope of the factors considered while planning, Ali expressed his view as follows:

> *We make the planning according to the student level and the teaching materials that can be used. If we lack teaching material, we make a plan accordingly.*

Aras explained what he considered in lesson planning:

> *I do a plan according to student motivation, students' physical-psychological situation, and learning environments. I check if the student is motivated or not. I will make progress according to them.*

"Question Generating" Strategy

Table 4 presents codes that comprise participants' experiences with the question-generating strategy.

Table 4.

Codes Related to the "Generating Questions" Strategy

Questions		Codes	Participants					
			Hale	**Aras**	**Ali**	**Naz**	**Beril**	**Su**
Do you want your students to question what you teach? Why?	Yes	A sense of wonder	X		X	X		X
		Better learning	X	X		X		
		Doing research						X
Is the originality of the questions asked by the students important? Why?	Yes	To lead individuals in different directions		X				
		To draw attention		X				
		To reveal creativity						X
		To direct the course flow						X
		To orientate to Meaningful learning				X X		
	No	The important thing is to ask questions	X		X		X	
Would you encourage your students to ask questions? Why?	Yes	To remind					X	
		To motivate		X				
		For active participation		X		X		
		To promote	X			X		
		To make reinforcement						X
		To build trust				X		
		It is a step toward learning			X			

All participants stated that they want their students to question what they have learned. For example, Naz stated that students' inquiries create a sense of curiosity and provide better learning, explaining her thoughts as follows:

> *The questioning student learns better when they do not understand when they are reading or when they have a question mark in their mind, they are asking with more interest. Why is that so? Tell me why? The questioning student always learns better.*

As far as the students' need to ask original questions, three participants stated that it is important that the students' questions are original. For example, Aras stated:

Originality is critical. An original question is also of great interest. I think the more original the question is; the more it will lead other students to think differently.

On the other hand, Beril stated that the originality of the questions is not important:

It is not important. The important thing is to remove the question marks of the children.

Additionally, all of the participants stated that they encouraged students to ask questions. For example, Aras stated that he motivated students to ask questions:

I motivate them. Therefore, I include activities where students can actively participate and play an active role and ask questions.

"Choosing Consciously" Strategy

Table 5 displays the codes relevant to the teachers' experiences of choosing a conscious strategy for metacognition.

Table 5.

Codes Related to the "Choosing Consciously" Strategy

Questions	**Codes**		**Participants**					
			Hale	**Aras**	**Ali**	**Naz**	**Beril**	**Su**
Would you allow students to make their own choices? Why?	Yes	To motivate				X	X	
		To understand the subject				X	X	
		To do research					X	
		To make progress		X				
		To plan themselves		X				
		To lead to interests and wishes	X					X
		To select freely			X			
Do you make students aware of the reasons for their preferences? Why?	Yes	To justify their preferences		X		X		X
		To improve justification skills	X					
		To draw attention						X
		To increase awareness				X	X	X

		To realize learning			X			
		To improve explanation ability				X		
Do you want your students to think about the results when choosing? Why?	Yes	To make the talents stand out	X					
		To redirect	X			X		
		To encourage	X					
		To enable them to evaluate			X		X	X
		To notice the results		X				

All participants stated that they allowed the students to make their own choices. In this context, Hale explained that she allows students to choose according to their interests and wishes:

> *I designate projects. We sort them into items. They select certain projects among them based on their interest. I also confirm if the project is suitable. But their choices are more important.*

All the participants stated that they enabled their students to become aware of the reasons for their choices. For example, Su stated that students' thinking about the reasons for their preferences is beneficial in terms of justifying their preferences, attracting attention, and increasing their awareness. She said:

> *If they are working on a subject, they need to question why they are doing it and why they are working on it. Otherwise, they do not want to search for something they are not aware of. In other words, the subject does not draw students' interest. For this reason, an efficient product does not emerge as a result.*

Additionally, all the teachers stated that they made their students aware of the results of their choices. For example, Aras stated:

> *Students need to be aware of how their choices will result in. I think this is important in determining the steps they take in line with their choices.*

"Evaluating with Multiple Criteria" Strategy

Table 6 shows the codes related to the teachers' strategies to allow their students to evaluate the activities performed in the class according to certain criteria.

Table 6.

Codes Related to the "Evaluating with Multiple Criteria" Strategy

Questions	Codes		Participants					
			Hale	Aras	Ali	Naz	Beril	Su
Can you include activities that will make students think? Why?	Yes	To motivate		X				
		To increase participation		X				
		To make them think				X		
		To discuss			X			
		To adapt to daily life				X		
Would you like students to evaluate your activities? Why?	Yes	To provide critical thinking skills						X
		To reveal different ideas						X
		To foster creativity						X
		To increase entrepreneurship						X
		For peer review			X			
		To get feedback	X	X		X	X	
Would you like students to evaluate themselves at the activities? Why?	Yes	To make it understood	X					
		To increase achievement		X				
		To increase awareness		X				
		To improve self-confidence		X				
		For self-criticism				X		X
		To notice the shortcomings						X
		To prevent misconceptions				X		

Participants testified that they included activities in their lessons that allowed students to think. For example, Naz included these activities to make them think with questions and adapt their learning to their daily life:

> *We start with the first thought-provoking questions at the beginning of the course. For example, did you realize this in your daily life? We both connect with everyday life and reveal what they know by asking them questions before teaching.*

Participants also stated that they wanted their students to evaluate the activities they did in the lessons. For example, Aras said:

> *I would like to get the opinions of the students to develop or not to implement an activity that does not motivate and produce a positive result.*

Additionally, participants stated that they enabled the students to evaluate themselves. For example, Su said:

> *Students express it if they have shortcomings. In the process, children can criticize themselves honestly, saying that if I did this, it would be better. Or if they think they have learned, they express it.*

"Taking Credit" Strategy

We analyzed how teachers used the taking credit strategy. Table 7 indicates the codes reached as a result of the analysis.

Table 7.

Codes Related to the "Taking Credit" Strategy

Questions	**Codes**		**Participants**					
			Hale	**Aras**	**Ali**	**Naz**	**Beril**	**Su**
Would you let your students give feedback to each other? Why?	Yes	To create a collaborative environment		X				
		To exchange ideas		X				
		For peer instruction		X	X			X
		To listen to each other	X					
		To question					X	
		To develop different ideas	X			X		
Would you make students aware of their achievements? How?	Yes	By using reinforcements	X			X	X	
		By motivating					X	
		By forming a portfolio		X				
		By self-evaluation		X				
		By exhibiting works					X	X
		By reminding their achievement			X			
Would you ensure that students respect different thoughts and be tolerant? How?	Yes	By empathy	X		X	X		
		By making speeches		X			X	
		In cooperation with the guidance service		X				
		By controlling the process						X

As Table 7 shows, the participants stated that they enable students to give feedback to each other. For example, Aras expressed his views as follows:

> *I let them communicate with their friends. This improves collaborative learning. They exchange ideas with other friends.*

Regarding the second question, Beril said that she gave reinforcement to her students, motivated them, and allowed them to exhibit their works:

> *I exhibit their successful projects at the teacher's desk so that all students can see them. This motivates them. Or sometimes I make them applause.*

In the third question, the participants stated that they behave in a way that would create a trusting environment in the classroom. For example, Naz explained she had conversations with the students to develop respect and tolerance:

> *For example, when a student answers a question, another student may think that the answer is wrong. The answering student can defend his/her view against others. We teach students that not everyone can agree, there may be different opinions, and they must respect each other.*

"Outlawing I Can't" Strategy

We analyzed the responses of science teachers to determine their views on the strategy of outlawing "I can't," and we present the codes in Table 8.

Table 8.

Codes Related to the "Outlawing "I Can't" Strategy

Question	Codes	Participants					
		Hale	Aras	Ali	Naz	Beril	Su
What do you do for your students' expressions such as "I don't know what to do" or "it is very difficult"?	Encouragement	X	X			X	
	Empathy			X			
	Applying to the guidance service			X			
	Orientation		X		X		
	Developing self-confidence				X		

Table 8 indicates that the participants exhibit many behaviors when their students struggle with difficulties. For example, when students do not know what to do about a problem, Ali tries to develop confidence and direct their students:

> *Foremost, I get involved from the outside, I think as a student, and by empathy, I think about what the student should do. If I cannot solve the problem on my own, I will contact the guidance service and look for solutions in cooperation in this direction.*

"Reflecting Students' Ideas" Strategy

One of the findings of this study is the integration of the strategy of "reflecting students' ideas" into the participants' instructional practices. We present the codes reached within this scope in Table 9.

Table 9.

Codes Related to the "Reflecting Students' Ideas" Strategy

Question	Codes		Participants					
			Hale	Aras	Ali	Naz	Beril	Su
Would you make your students reflect their ideas in the classroom? What do you do in this context?	Yes	Creating a discussion environment	X					X
		Encouragement					X	
		Letting students speak				X	X	
		Doing interesting activities		X				
		Designing projects			X			
		Doing group activities						X

Table 9 shows that the participants have different ideas in terms of encouraging students to reflect on their ideas in the classroom. For example, Su stated that she creates a discussion environment and does group activities. She explained:

> *I usually create discussion environments. For example, I get the opinions of students about environmental problems, I get group work done and I want them to present the results of their group work. I think there are many ways children can express their thoughts.*

"Labeling Student Behaviors" Strategy

We examined teachers' thoughts on their use of the "labeling student behaviors" strategy in their lessons and present the codes obtained from teachers' explanations in Table 10.

Table 10.

Codes Related to the "Labeling Student Behaviors" Strategy

Question	Codes	Participants					
		Hale	Aras	Ali	Naz	Beril	Su
What do you do to make students aware of their activities and behaviors?	Realize the results				X		
	Making suggestions			X			
	Reinforcing	X			X		X
	Peer evaluation		X				

	Completing the missing parts				X	
	Motivate				X	
	Emphasizing	X				
	Raising awareness					X

As seen in Table 10, all participants stated that they used the labeling student behaviors strategy in different ways. For example, Naz makes use of this strategy by making students notice the results of their behaviors. Her thought on using this strategy is as follows:

> *Let's say we had an activity, a student said something different. I try to mention what he did. And I make him think about it because some students behave in a way that comes to their minds without thinking. But when he learns the consequences of his behavior, he can react differently.*

"Clarifying Students' Terminology" Strategy

We examined teachers' views on the use of the "clarifying students' terminology" strategy in the interviews. Table 11 indicates the codes determined in this context.

Table 11.

Codes Related to "Clarifying Students' Terminology" Strategy

Question	**Codes**	**Participants**					
		Hale	**Aras**	**Ali**	**Naz**	**Beril**	**Su**
What do you do when students use incomprehensible words to express their thoughts?	Asking for an explanation	X	X	X		X	X
	Defining the wrong expression				X		
	Asking another student for an explanation	X					
	Completing the missing parts		X	X			X
	Asking to rethink		X				

Almost all participants stated that they would ask for an explanation for what was not understood in using the clarifying students' terminology strategy. For instance, Aras said:

> *I ask them to explain when they use words that are not understood. This is one of the most common problems. Because students are using their local accent. Even in the local accent, I want them to explain.*

"Role-Playing" Strategy

We examined teachers' experiences of using role-playing strategies to improve students' metacognition and present the codes for these practices in Table 12.

Table 12.

Codes Related to the "Role Playing" Strategy

Question		Codes	Participants					
			Hale	Aras	Ali	Naz	Beril	Su
Do you think the use of role-playing techniques in science classes is effective in increasing students' metacognition? Why?	Yes	Feeling free			X		X	
		Self-recognition		X				
		Accepting differences		X				
		Gaining different perspective			X		X	

As Table 12 shows, participants stated that role-playing is effective in improving students' metacognition. For example, Beril explained her view as follows:

> *Students can be a bit brutal when criticizing each other or commenting on someone else. Things change a little more when I want them to put themselves in someone else's shoes. For example, while watching a video, students can criticize the person in the video. However, when you ask your students to think that they may be in the situation of the person in the video, they change their thoughts.*

"Journal Keeping" Strategy

We analyzed teachers' opinions on the use of the "journal keeping strategy" to increase metacognition. Table 13 indicates the codes obtained in this context.

Table 13.

Codes Related to the "Journal Keeping" Strategy

Question	Codes		Participants					
			Hale	Aras	Ali	Naz	Beril	Su
Do you ask your students to keep a journal about science lessons? Why?	Yes	Useful					X	
		Increases awareness					X	
		Ensures listening to the lesson carefully					X	
		Preferring oral evaluation	X	X	X			
	No	Intensive curriculum				X		
		Not useful						X
		Time is limited				X		

Among the participants, only Beril stated that she had her students keep a journal related to science lessons. Other participants do not ask their students to keep journals. Beril stated that she had her students keep journals since it is useful; science journals increase students' awareness and ensure active listening in the lessons. She explained:

> *Students keep a journal about what they learn from science lessons. They write what they have left in mind. When everyone writes something, they complete each other's mistakes. I found it very useful. They see what they are missing. They listen to the lesson more carefully because they know that they will write a journal in the next lesson.*

On the other hand, Naz explained she does not ask to keep journals due to the intense curriculum and limited time:

> *Our previous curriculum was very intense and we had limited time. But we are a little more flexible in the updated curriculum. Maybe I can use this method (keeping journals) in the future.*

"Modeling" Strategy

As the last strategy, we examined teachers' experiences of using the "modeling" strategy to increase students' metacognition. Table 14 shows the codes for these practices.

Table 14.

Codes Related to the "Modeling" Strategy

Questions	Codes		Participants					
			Hale	Aras	Ali	Naz	Beril	Su
Do you think you are an example for your students with your metacognitions and thoughts? Why?	Yes	Change in the student profile		X				
		Behaviors are effective	X					
		Opening different doors					X	X
		Our ways of thinking are important			X	X	X	
Would you like students to evaluate your activities? Why?	Yes	To draw students' attention				X		
		Due to negative reactions	X					
	No	Due to loss of impact on student						X

All participants think they are an example to their students with their metacognition and thoughts. For example, Naz explained:

> *So maybe I am. Because some students asked me questions such as "How were you when you were a student?" "What were you doing?" I give examples from myself. I tell them that I would take small notes before exams. I see that many students are practicing it. I see small papers in their hands. I see they take notes during the lesson at the same time. So I think I am an example.*

With regard to modeling strategy, four of the participants encouraged their students to evaluate the teacher and the lesson, while Hale and Su stated that they did not ask their students to evaluate themselves. For example, Naz explained:

> *I try to get feedback on whether they love the activities, and whether it is useful if they find them fun. Some students do not want to participate in the activities. I try to get feedback on how can I draw their attention better.*

Su, on the other hand, defended the idea that her influence on students would decrease if she asks the students to evaluate her. She explained:

> *I don't want one-on-one evaluation, but I can sometimes get their opinions without realizing it. They are already voicing it, but I do not directly ask them to evaluate me or what is your comment about me. I get their comments in the process.*

Discussion of the Findings and Recommendations

This study aims to determine metacognition strategies that science teachers use in science lessons and activities they can perform within the scope of these strategies. The research findings indicated that science teachers define metacognition with expressions such as being aware of one's knowledge, knowing how to learn, and being aware of what one thinks. Although the concept of metacognition is defined as "thinking about thinking" in its most general and basic form (Papleontiou-Louca, 2003), it is a complex concept that is divided into many subcomponents (Zohar & Ben-David, 2009). Flavell (1978), who is accepted as the pioneer in the field of metacognition, defined metacognition as "information and regulation about cognitive activities in learning processes." The concept of metacognition is not sufficiently explored (Ben-David & Orion, 2013). Our findings demonstrate that science teachers' definitions related to the metacognition concept are more developed and more compatible with the definitions in the literature.

Planning

Effective planning of lessons improves students' metacognition by enabling students to monitor and regulate their cognitive activities (Akın, 2006). It can improve students' metacognitions if the teacher shares instructions about the course before starting the lesson, asks questions about the course progress during the lesson, and asks them to evaluate the lesson at the end of the lesson (Costa, 1984). A teacher aiming to improve students' metacognitions should plan what instructions to give before the lesson, what questions to ask to reflect students' thoughts during the lesson, and what processes to follow to reveal students' evaluations at the end of the lesson.

The findings of our study revealed that science teachers generally do plan before the lesson. The teachers stated that they took into consideration the objectives of the lesson, student level, learning environment, teaching materials, students' readiness, and time factors. Participants stated that they informed the students about the problems they would encounter in the activities and the rules to be followed during the activities, and they made the evaluation of the activities. Regarding the use of the planning strategy, although the teachers are generally considered sufficient, they need to plan their lessons so that their students have more opportunities to speak and reflect on their thoughts and develop metacognition. In other words, the voice that rises in the classroom should be the students' voice rather than the teachers' (Schoerning et al., 2015). In our study, science teachers stated that using student voice and their self-reflection was an impotent component of lesson planning.

Generating Questions

Asking a qualified question is an indication of in-depth thinking (Ciardiello, 1998). Therefore, students should create task-related questions in their minds before starting a task to better understand the issue. Also, they should continually watch and evaluate whether they can understand the subject, associate the information they have learned with their existing knowledge, and give different examples. By doing this, they take the necessary steps to eliminate difficulties and concerns. All these

processes make individuals aware of their cognitive activities, and eventually, their metacognition improves (Costa, 1984; Sanacore, 1984).

Research indicates that when students are engaged in self-reflection, teachers' practices become more effective (Hartman, 2002). Hartman (2002) asserts that teachers wanted their students to come prepared by researching the subject, studying the subject, and preparing the material. The result of our study revealed that science teachers encourage their students to ask questions to be curious and motivated and to conceptualize the subject. Moreover, they take notice of whether the questions asked by the students are original. The importance of asking qualifying questions can hardly be overestimated: "teach somebody how to ask questions and she or he will learn how to learn for the rest of his/her life" (Papleontiou-Louca, 2003, p. 19). Therefore, science teachers should actively use the generating questions strategy (Yıldırım, 2012), which is also one of the findings of our study.

Choosing Consciously

Teachers can contribute to the development of students' metacognition by making them think about the results of their choices. Thus, students can establish a cause-and-effect relationship between their achievements/failures and their choices. The non-judgmental feedback given by teachers improves students' metacognition by making them aware of their behaviors (Costa, 1984; Papleontiou-Louca, 2003). One of the findings of our study is that science teachers encourage their students to think for themselves, which, in turn, makes them more motivated. Thus, the "choosing consciously" strategy proves to be effective, as this study asserts.

Evaluating with Multiple Criteria

Teachers can improve their students' metacognition by encouraging them to evaluate the activities or behaviors in the lessons according to more than one criterion. Therefore, teachers should ask their students to evaluate what is useful in an activity or lesson, what is not beneficial, what they like and dislike, or what are the positive and negative sides of an activity (Blakey & Spence, 1990; Costa, 1984).

One of the findings of our study is that science teachers highly motivate their students to evaluate their learning experiences based on multiple criteria. Therefore, nurturing students' critical thinking skills can be very beneficial to science teachers' instructional practices.

Taking Credit

Another important finding of our study is that the use of the "taking credit strategy" proves to be highly effective for teachers to encourage peer feedback among their students. This confirms other research about raising students' awareness about their behaviors (Costa, 1984). We found that teachers use the "taking credit" strategy at a high level. Participants of this study stated that they wanted students to empathize, be motivated, and create environments suitable for peer instruction. Such instructional practices can improve students' metacognition (Yıldırım, 2012).

Outlawing "I Can't"

Students sometimes feel helpless when they face difficulties in their lessons. They express their desperation with such phrases as "no matter what I do I cannot learn," "I cannot do it," and "I do not know how to do it." In such cases, teachers may ask what information or material they need to fulfill the task assigned and what skills they lack. In this way, students can fill in the gaps between their current knowledge and what they need to know. In this way, students can develop permanent attitudes and determine the strategies to reach the information they need (Costa, 1984).

The study's findings showed that teachers use certain strategies for their students to cope with the difficulties. Encouraging, directing, empathizing, and applying the guidance service when students are desperate against a situation or task are named by science teachers as the most frequently used strategies. The reason behind the students' desperation may be their epistemological beliefs. According to Schommer (1990), students with naive beliefs in the innate ability dimension of epistemological beliefs hold that innate qualities such as intelligence are more important for achievement, while people with sophisticated beliefs tend to believe in the power of effort and hard work. Thus, students with sophisticated epistemological beliefs can overcome their fears of failure by working harder. Therefore, providing opportunities for students to question and develop their epistemological beliefs can be very helpful to overcome their despair and enhancing their metacognition.

Reflecting Students' Ideas

Teachers should ask their students to express their opinions in different ways in their own words. In this way, students have the opportunity to listen not only to other students' thoughts but also to their own thoughts. Thus, their metacognition improves (Costa, 1984; Trilianos, 1997). According to Bloom's taxonomy, students' expressing their friends' and teachers' thoughts in their own words shows that they comprehend the subject (Bümen, 2006). Therefore, when teachers ask their students to reflect on their ideas, they enable their students to develop both their cognition and metacognition.

One of the findings of our study indicated that teachers provide a discussion environment, give students a voice, and employ group work to create environments where students can reflect on their ideas. Supporting our finding, Tatar (2004) stated that students should interact and listen to each other based on trust and respect in productive and effective classrooms. Therefore, asking students to convey their ideas in their own words, producing new ideas, and comparing their ideas with their friends can be considered fruitful practices to make use of the reflecting students' ideas strategy.

Labeling Student Behaviors

When teachers introduce and explain students' cognitive processes, students will become more aware of their behavior (Costa, 1984; Trilianos, 1997). For example, the teacher can define and explain their students' behaviors with the expressions such as "what you say is a hypothesis," "you have followed the scientific process steps," or "you have established a hypothesis now." In this way, students can organize their thoughts, explain what they want to say to communicate effectively, and improve their metacognition (Papleontiou-Louca, 2003).

One of the findings of our research is that science teachers use various techniques to make their students aware of their activities and behaviors. Thus, they use the labeling student behaviors strategy in a way that improves students' metacognition. In this regard, science teachers try to make students aware of their behaviors by giving suggestions, reinforcing, and emphasizing desired behaviors.

Yıldırım (2012) claims that students whose behaviors are recognized become more successful and accepted by their society. Therefore, when teachers notice and explain behaviors and thoughts of their students, they not only improve students' metacognition but also help them increase their achievement and make their students feel valued.

Clarifying Students' Terminology

Students may use vague concepts and descriptions that are not understood by others. They think that other students and their teachers understand their concepts the way they understand them. In such cases, teachers should ask their students to explain concepts that are not clear and understandable. In addition, paired problem-solving strategies can also be used. In this strategy, students are matched in pairs. While one of the students explains the thinking processes related to the solution of a problem, the other student listens and asks questions (Blakey & Spence, 1990). In this way, students can develop their metacognition because they will monitor their ideas and notice that their understanding is incomplete or incorrect (Costa, 1984).

The findings of our research showed that science teachers ask their students to justify their thinking. Also, one of the participants stated that he would justify the misused concepts by himself instead of asking students to clarify what they mean. Papleontiou-Louca (2003) claims that clarifying students' terminology allows learners to prepare more deliberately, aid the learning process, and transfer the principles used to comparable circumstances. Thus, asking the student to justify their thinking is a more intended approach compared to teacher prove justification. Therefore, science teachers are said to enhance their students' metacognition by using the clarifying student terminology strategy since most of them asked their students to justify ambiguous concepts.

Role-Playing

In the role-playing and drama activities, students play different roles and try to reflect the thoughts and character of the role they play. This improves students' metacognitions (Costa, 1984; Demir, 2009; Papleontiou-Louca, 2003).

The findings of our research revealed that science teachers use various techniques during role-playing and drama activities to develop students' metacognition. Brainstorming is the most used technique. In addition, techniques such as question-answer, six hats, cooperative learning, and learning by doing are emphasized by teachers. Thus, teachers use the role-playing strategy effectively in enhancing metacognition. In addition, the teachers encourage students to empathize in the role-playing activities. In this way, along with the development in their metacognition, students notice different perspectives and will move away from egocentric thinking (Trilianos, 1997).

Journal Keeping

Journal keeping is another strategy that can be used to improve students' metacognition. Students who keep journals synthesize their thoughts and reflect them in a symbolic form. The journals also help students to realize their inner perceptions and changes in these perceptions over time (Blakey & Spence, 1990; Costa, 1984; Özsoy, 2008).

The findings of our research indicated that only one of the participants asks students to keep science journals and monitors their development. Students' cognitive and metacognitive developments can be monitored using journals. Furthermore, journals enable students to make self-evaluations. However, as in previous studies (du Toit, 2009; Yıldırım, 2012), the present study showed that among the metacognition enhancing strategies, keeping a journal is the least used strategy. Students who will keep journals reflect on their reasoning, make a note of ambiguities and inconsistencies, and discuss how they coped with issues. Therefore, the self-assessment and self-regulation of students who do not keep a journal will be lower than those who keep a diary (du Toit, 2009).

The findings of our study also revealed why teachers do not use the journaling strategy. Teachers often put forward excuses such as time limitations and oral evaluation. The learning levels of students can be evaluated verbally in lessons. Even in these oral evaluations, metacognition develops as students can find the opportunity to reflect on their thoughts and knowledge. However, oral evaluations should not deter teachers from asking their students to keep a journal because these diaries let teachers review their students' progress. In addition, journals have advantages since they enable introverted students who are not willing to participate in classroom interactions to reflect their ideas (Georghiades, 2004). Therefore, teachers should include the journal keeping strategy more in their lessons as a tool to develop students' metacognitions.

Modeling

According to Costa (1984), the modeling strategy is more effective than any other strategy in metacognition development because students learn by imitating the surrounding adults. Therefore, teachers who clearly show their metacognition skills by sharing their goals and achievements with their students and explaining the reasons for their behavior will be good role models for their students (Blakey & Spence, 1990). By thinking aloud in their lessons, teachers can make their students realize that problem-solving is a slow and complicated process. Thus, they become a model for their students (Saban, 2000).

Findings of our research showed that the teachers think they are good role models for their students. Teachers believe they are effective on students and shape their thoughts to a great extent. Similarly, Yıldırım (2012) reported that teachers use the modeling strategy at a high level. Therefore, teachers use modeling strategies effectively to enhance their students' metacognition.

Conclusion

In summary, our findings indicated that the science teachers' definitions of metacognition are compatible with the definitions in the literature. Also, science teachers generally use the metacognition-enhancing strategies developed by Costa (1984) effectively, except for the journal keeping strategy.

Based on these results, we suggest a workshop to teach how to use these metacognition-enhancing strategies effectively to in-service and preservice teachers. Also, additional research can be conducted to test whether there is a relationship between teachers' and their students' metacognition levels. Moreover, in Turkey, the research on metacognition was mostly done in Turkish (language) education. The participants of this study were in-service science teachers. Further research on metacognition can be carried out in different fields of education.

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