Implementation of Strategy Instruction to Promote Pre-Service Chemistry Teachers' Self-Regulated Learning Skills

Funda Ekici
Gazi University, Turkey
https://orcid.org/0000-0001-7534-368X

Basri Atasoy
Gazi University, Turkey
https://orcid.org/0000-0003-1683-2381

Abstract

This study aimed to promote self-regulated learning skills in pre-service teachers, and to this end, a two-year Self-Regulated Learning Skills Development (SLSD) Plan for pre-service chemistry teachers was developed. In this SLSD plan, the strategy instruction was conducted in an integrated way into the content courses of the chemistry education curriculum. The strategy instruction was carried out in four parts: "time management strategies", "reading comprehension and summarization strategies", "writing strategies" and "questioning strategies". In addition, metacognitive strategies used by the pre-service teachers during the strategy instruction were also examined. Semi-structured interviews, self-monitoring forms, field notes, and student-generated questions were used to collect data to identify the strategies that the pre-service teachers used and determine the changes that occurred as a result of the application of these strategies. The data were analyzed using descriptive and content analysis methods. It was determined that both the frequency of use and the diversity of the strategies used increased in time management strategies, reading comprehension and summarizing strategies, and writing strategies. In questioning strategies, when the quality of the questions created by pre-service teachers was examined, it was determined that there was an increase in the quality of these questions in terms of "thinking level" and "content", but there was no regular trend in terms of "chemistry understanding levels". It was observed that most of the pre-service teachers also applied metacognitive strategies during strategy instruction. In the light of the results of this study, suggestions on promoting self-regulated learning skills in pre-service teachers are provided for chemistry teacher education, and chemistry education researchers.

Keywords: Strategy Instruction, Self-Regulated Learning, Pre-Service Chemistry Teachers, Learning Strategies

Introduction

Self-Regulated Learning (SRL)

Self-regulation is defined as students' cognitive, metacognitive, motivational, and behavioral active participation in their own learning processes (Zimmerman, 1990). In the last three decades, many studies on self-regulation have been conducted and many self-regulated learning models have been developed (Kistner et al., 2010). In all of these different models, self-regulated learning skills have been shown as skills related to planning, monitoring, controlling, and evaluating one's own cognition, metacognition, motivation, and behaviors (Boekaerts, Pintrich, & Zeidner, 2000; Zimmerman, 2000).

Learners with self-regulation skills can motivate themselves and have metacognitive awareness, they are also academically successful and approach their future in an optimistic manner (Altun, 2005). Considering these characteristics that learners with strong self-regulation skills have acquired, self-regulation can be an answer to the expectation of giving lifelong learners in today's societies the opportunity to take responsibility for and regulate their own learning.

The "Learning to learn" skill is one of the competencies that students should have in the present secondary education chemistry curriculum (see Ministry of National Education, 2018). Bearing in mind that it is the teachers' fundamental responsibility to develop students' skills and teachers are required to be experienced in self-regulated learning, how to promote it, and what to do in special situations that can be encountered in practices, it is clear that studies aimed at promoting pre-service teachers' self-regulation skills are valuable.

It would be natural to expect that pre-service teachers who are well-equipped in self-regulation practices would have students who are also well-equipped in self-regulated learning skills (Otto, 2010). Self-regulated learners are aware of their strengths and weaknesses in their learning process, and thanks to this awareness, they can monitor and arrange their behaviors in line with their learning goals. This situation enables them to promote their learning strategies (Weinstein, Acee, & Jung, 2011). Learning strategies are students' behaviors and thinking processes (Muteti et al., 2021). These strategies are purposeful behaviors that show how the learner processes information, and each of the techniques that facilitate the individual's learning (Weinstein & Mayer, 1986). These strategies may involve some simple studying skills, such as underlining important points in a text, or complex thinking processes, such as using analogies (Weinstein, Jung, & Acee, 2010). Although these strategies are classified in different ways in the literature, one of the most commonly used is the classification by Weinstein and Mayer (1986). According to this classification, cognitive learning strategies are considered in three categories, comprising rehearsal, elaboration, and organizational strategies. Unlike rehearsal strategies, elaboration and organizational strategies provide a deeper understanding of the material to be learned. In other words, these strategies help students integrate new knowledge into their learning goals, and use reasoning and problem solving (Weinstein et al., 2018).

In addition to cognitive learning strategies, metacognitive strategies have a significant impact on learners' academic performance. According to the literature, metacognition consists of two main components, which are knowledge about cognition and regulation of cognition (Paris & Winograd, 1990; Schraw, Crippen, & Hartley, 2006; Schraw & Moshman, 1995). Knowledge about cognition is what a learner knows about his or her own cognitive processes and includes three different types of metacognitive awareness, which are declarative knowledge, procedural knowledge, and conditional knowledge (Schraw & Dennison, 1994). Declarative knowledge includes the individuals' knowledge of themselves as learners and the factors that affect their performance. Procedural knowledge is knowing how to use which strategies to accomplish a task. Conditional knowledge is knowing when and why to use the strategies (Schraw & Moshman, 1995). Regulation of cognition, on the other hand, involves the planning, monitoring, and evaluating processes that a learner uses to control his or her own thinking and learning (Schraw & Moshman, 1995). Planning involves selecting the appropriate strategy and identifying the necessary resources for studying. Monitoring means analyzing performance and comparing it with previous experiences. Evaluation involves analyzing one's self, one's performance, and the effectiveness of the strategies used.

Self-Regulated Learning Skills Development (SLSD) Plan

The social cognitive theory, developed by Albert Bandura, highlights the importance of both cognitive and motivational components in self-regulated learning. According to this theory, self-regulated learners can establish their own academic goals, are aware of the cognitive, metacognitive, and motivational processes corresponding to these goals, and possess the skills to control, monitor, and regulate these processes (Zimmerman, 1989).

For this reason, both components (cognitive and metacognitive) were addressed in the practices of the self-regulated learning skills development (SLSD) plan. The SLSD plan is summarized in Table 1.

Table 1 Self-Regulated Learning Skills Development (SLSD) Plan

Which Component of SRL?	What was Implemented?	Scope	Period
Cognition Metacognition	Strategy instruction Basic learning strategies instruction Examination of metacognitive strategies	General Chemistry I-II Inorganic Chemistry I-II	2 years

Purpose

The purpose of this study was to develop the skills of pre-service chemistry teachers', such as taking responsibility for their own learning, actively participating in the learning process, and controlling this process by providing the SLSD practices to them. In line with this purpose, this study focused specifically on equipping pre-service teachers with the knowledge of how and when to use which strategy, and use appropriate and various strategies to regulate their learning, by enhancing their cognitive and metacognitive strategy knowledge.

Scope

It has been recommended to teach cognitive, metacognitive, and motivational strategies together because both cognition and motivation are considered in the self-regulated learning model, which is grounded on the social cognitive learning theory (Hofer, Yu, & Pintrich, 1998; Wolters, Shirley, & Pintrich, 1996). This study was based on the self-regulated learning model (Fig. 1) suggested by Schraw, Crippen, and Hartley (2006) for teaching science. The SLSD plan, prepared in line with this model, focused only on the cognition and metacognition components of self-regulated learning. In the strategy instruction carried out in this SLSD plan, there are cognitive aspects such as summarizing, and metacognitive aspects such as self-monitoring.
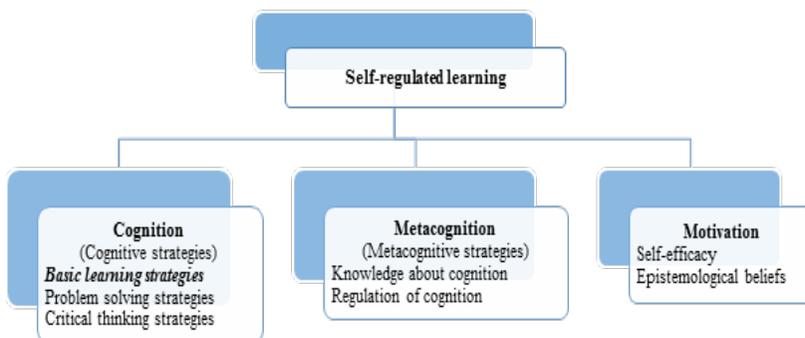

Figure 1 Self-Regulated Learning Model (Schraw, Crippen, & Hartley, 2006)

Integrated Practices

Based on the model in Fig. 1, the SLSD plan was prepared for pre-service teachers. The SLSD plan is shown in Table 1, where it can be seen that this plan was carried out over a period of two years. The plan was integrated into the content courses of the chemistry education curriculum (General Chemistry I-II and Inorganic Chemistry I-II courses). Strategy instruction that is not carried out according to domain-specific could result in students perceiving the strategies as course-specific strategies and therefore finding it difficult to transfer these strategies to other courses; however, strategy instruction practices that are integrated into the curriculum can be more useful for students (Donker et al., 2014; Simpson et al., 1997). A two-year plan was prepared. Because it was believed that strategy instruction practices that are both long-term and integrated into the chemistry education curriculum can yield better outcomes (Kadioglu-Akbulut & Uzuntiryaki-Kondakci, 2021).

The implementation lasted two years and consisted of practices of developing learning strategies for pre-service teachers and examination of metacognitive strategies in this process.

Studies regarding domain-general and domain-specific practices on strategy instruction exist in the literature; however, domain-general strategy instruction practices may not produce the expected results (Otto, 2010). The instruction of cognitive strategies constitutes the first and most important stage of the model, not only in the one presented in Figure 1, but also in the other self-regulated learning models.

The literature presents two ways in which strategy instructions can be carried out, implicit and explicit. Students are not provided with any prior information indicating that the strategy being taught might be an effective strategy in implicit instruction. On the contrary, in explicit instruction, students are clearly told that it is a learning strategy activity that they are taking part in and that the activity can help to improve their own performances when performing an activity on strategy instruction, and they are also informed about why the strategy is important (Kistner et al., 2015). Implicit instruction encourages the use of a particular strategy but fails to be successful when applying this strategy in a different situation comparing these two kinds of strategy instruction (Dignath-van Ewijk & van der Werf, 2012; Veenman, 2011; Veenman, 2018). In contrast, explicit instruction enables students to apply the strategy to similar situations and increases the permanence of strategy use (Kistner et al., 2010). For this reason, this study applied explicit instruction where strategies were introduced and then instructed. A number of studies carried out on the use of strategy instruction to enhance self-regulated learning have involved different educational levels, from primary school to university (Dignath & Büttner, 2008; Kadioglu-Akbulut & Uzuntiryaki-Kondakci, 2021; Pressley & Woloshyn, 1995; Zimmerman, 1989). These studies focused on time management, reading comprehension, summarization, and writing, which are the most important inadequacies of students (Hattie, Biggs, & Purdie, 1996; Zimmerman, Bonner, & Kovach, 1996). Furthermore, questioning which plays a key role in students' comprehension, and in

their monitoring and control of this comprehension (Kaberman & Dori, 2009b), was another important part of this study.

One of the primary reasons behind the need for this study is to address the fact that university students do not know how to learn (Nilson, 2013; Singleton-Jackson, Jackson, & Reinhardt, 2010); that is to say, they maintain the habits they practiced in high school, do not take responsibility for their own learning and strictly rely on others to teach them (Dembo & Seli, 2004). Furthermore, among their other observed inadequacies, these students are unable to produce ideas on how to improve their learning since they are not aware of their learning characteristics (Chan & Bauer, 2016; Sebesta & Bray-Speth, 2017). This study, therefore, aimed to foster SRL skills in pre-service chemistry teachers, focusing specifically on their time management, reading comprehension and summarization, writing, and questioning strategies. In line with these aims, the following research questions were addressed:

- What were the changes in the basic learning strategies of pre-service teachers?
  - What changes occurred in the pre-service teachers' time management strategies (TMS)?
  - What changes occurred in the pre-service teachers' reading comprehension and summarization strategies (RCSS)?
  - What changes occurred in the pre-service teachers' writing strategies (WS)?
  - What changes occurred in the pre-service teachers' study strategies?
  - What changes occurred in the pre-service teachers' study strategies during teaching TMS?
  - What changes occurred in the pre-service teachers' study strategies during teaching WS?
  - What change occurred in the pre-service teachers' questioning strategies (QS)?
  - How did the quality of the questions asked by the pre-service teachers change by teaching QS?
- What are the metacognitive strategies used by the pre-service chemistry teachers during Basic Learning Strategies Instruction (BLSI) practices?

Methodology
Research Procedure

The study aimed to acquire the strategies classified as learning strategies by Zimmerman, Bonner, and Kovach (1996). These learning strategies are "time management strategies", "reading comprehension and summarization strategies", and "writing strategies". The researchers added "questioning strategies" to these three strategies, considering that it is known that students hesitate to ask questions in chemistry courses (Tsaparlis, 2016), and included them as part of the BLSI. All of the BLSI practices, including the interviews carried out at particular times, were completed in 29 weeks (14 weeks in the first year and 15 weeks in the second year).

The BLSI practices were performed in two years. The study was integrated into the General Chemistry (I, II) courses in the first year of the chemistry education curriculum and into the Inorganic Chemistry (I, II) courses in the second year (See Table 1). Normally, these courses are part of the curriculum as theoretical lessons (4 hours each week) and applied lessons (2 hours each week). But two extra hours of lessons were added for the BLSI practices to the weekly schedule of the course to avoid disturbing the progress of these courses. Of the researchers, two were present in the classroom as observers in the theoretical lessons and as a lecturer in both the applied lessons and the two extra lessons. In these lessons, chemistry-related activities were carried out with the participants. The BLSI practices were, therefore, incorporated into the content of General Chemistry and Inorganic Chemistry courses. As Table 2 indicates, the BLSI practices consisted of three parts: the 1st part of the BLSI, where the participants raised awareness regarding the importance of self-regulated learning, 2nd part and 3rd part of the BLSI, where the instruction of different learning strategies was performed.

Table 2 Basic Learning Strategies Instruction (BLSI) Practices and their Application Period

	BLSI Practices	Period
BLSI (1st Part)	Raising awareness on the importance of self-regulated learning and discussions to boost cognitive and metacognitive awareness	2 weeks
	Introduction to self-regulated learning skills and discussions on the necessity of them	2 weeks
BLSI (2nd Part)	Teaching "time management strategies"	3 weeks
	Interviews	3 weeks
	Teaching "reading comprehension and summarization strategies"	4 weeks
BLSI (3rd Part)	Teaching "writing strategies"	1 week
	Reminders and briefing on the new strategy instruction	2 weeks
	Teaching "writing strategies"	3 weeks
	Teaching "questioning strategies"	4 weeks
	Interviews	5 weeks
	Total	**29 weeks**

Participants

The study was conducted for 29 weeks with freshmen pre-service chemistry teachers enrolled in the chemistry department of the Faculty of Education of a state university. A total of 18 pre-service chemistry teachers (16 females, 2 males), whose ages ranged between 17–20 years, participated in the study.

Ethical Considerations

The necessary approval relating to the conduct of this study was obtained from the Head of the Chemistry Education Department. At the beginning of the study, the participants were informed about the research procedure. The participants were informed that they could participate in the study on a voluntary basis and withdraw from the study at any time they wished. The participants were provided with a written consent form before the study began. The

name of the state university chosen for the research was kept anonymous and pseudonyms were used to ensure the anonymity of the pre-service chemistry teachers' identities who participated in the research.

Data Collection Tools

Semi-Structured Interviews: Semi-structured interviews were conducted to determine the participants' time management, reading, comprehension, and study strategies. The metacognitive strategies of the participants were also determined during these interviews. The interviews were applied to all of the participants following the completion of the three-week or four-week loops conducted during the course of the strategy instruction. Here are some examples of interview questions: "What can you say about your studying time?", "Which method do you use to read and understand a text or an article?", "What is your favorite method?", "Do you benefit from your own drawings or summaries when studying a new text/ topic?", and "Are there any methods you apply that you consider being an indispensable study tool?". Before finalizing the questions, the views of two chemistry educators with expertise in metacognition and self-regulated learning domains were used to confirm the content validity of the interview questions. The interviews were recorded using a digital audio recorder and lasted approximately 30 minutes.

Self-Monitoring Forms: Throughout the teaching of the "time management strategies", "reading comprehension and summarization strategies" and "writing strategies", each week the participants filled out a self-monitoring form to make them aware and regulate their learning processes. The self-monitoring form was developed by Zimmerman, Bonner, and Kovach, (1996). In this study, three different self-monitoring forms were used. Self-monitoring form used in the time management strategies teaching is a table that allows participants to record information such as what they do while reading, when, where and with whom they study, etc. (See Appendix 1).

The self-monitoring form used in teaching "reading comprehension and summarization strategies" is a table that the participants recorded information on the day that they studied the text assigned, indicating the number of hours they studied, the number of main ideas they communicated per page, and the number of points highlighted in the summaries they made (See Appendix 2).

The self-monitoring form used in teaching "writing strategies" is a table in which the participants recorded information about what they did while writing, the time spent, the content of their article, etc. (See Appendix 3).

Field Notes: Field notes were taken regarding the classroom discussions. During the classroom discussions, a digital audio recorder was used to avoid missing any conversation during the instruction. The purpose of keeping field notes was to record the data that participants did not state in their self-monitoring forms, but that they said during class discussions. The learning experiences and remarkable situations of the participants in this process were kept as field notes.

Student Generated Questions: In the teaching QS, the participants were given interesting texts from the literature and scientific journals. They generated questions from these texts. The questions created by the participants each week were scored, and the changes in the quality of the questions asked by the participants were examined.

Table 3 shows which data collection tools were used to answer the research questions. As seen in Table 3, interviews, self-monitoring forms, field notes and student generated questions were used to collect data.

Table 3 Data Collection Tools Used in the Research

Research Questions	Which Data Collection Tool
What were the changes in the basic learning strategies of pre-service teachers?	
What changes occurred in the pre-service teachers' TMS?	Self-monitoring forms, the interviews, field notes
What changes occurred in the pre-service teachers' RCSS?	Self-monitoring forms, the interviews, field notes

What changes occurred in the pre-service teachers' WS?	Self-monitoring forms, field notes
What changes occurred in pre-service teachers' study strategies?	
What changes occurred in the pre-service teachers' study strategies during teaching TMS?	Self-monitoring forms, the interviews, field notes
What changes occurred in the pre-service teachers' study strategies during teaching WS?	Self-monitoring forms, the interviews, field notes
What changes occurred in the pre-service teachers' QS?	
How did the quality of the questions asked by the pre-service teachers change by teaching QS?	Student generated questions
What are the metacognitive strategies used by the pre-service chemistry teachers during Basic Learning Strategies Instruction (BLSI) practices?	**Interviews**

Data Collection Process

In Table 2, the BLSI practices and their application period were briefly introduced. The 1st part of the BLSI included questions such as "what is learning?", "when do you learn better?", and "what makes you learn better?" that was posed to the participants, and classroom discussions conducted to boost participants' cognitive and metacognitive awareness. In the 2nd part of the BSLI, the participants were given a text-based chemistry homework every week. The texts were taken from a chemistry book focused on particulate nature of matter (See Atasoy, 2004). The participants were asked to fill self-monitoring forms while studying this text. The following week, a quiz was given on this text, and the results from the quiz were then evaluated.

These consecutively following practices, were used in a loop for the teaching of the two categories (teaching time management strategies and teaching reading comprehension and summarization strategies) constituting the BLSI (Figure 2).
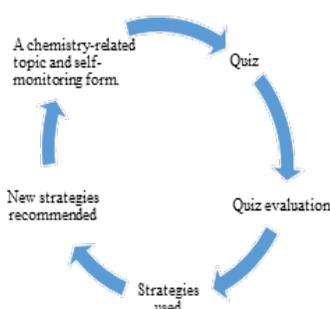

Figure 2 Loop Followed in Basic Learning Strategies Instruction (BLSI) 2nd Part

An approach different from the one applied in the 2nd part of the BLSI was adopted 3rd part of the BLSI to determine and improve the participants' writing strategies, which was the third basic learning strategy. The participants were not given chemistry-related texts but rather, asked to write a text on a chemistry topic. Their texts were examined and discussed in class. For the teaching of questioning strategies, the fourth basic learning strategy, the participants were provided approximately one-page long texts on an interesting chemistry topic each week and asked to prepare questions on these texts in the classroom. These questions were evaluated in terms of their different components, so it was aimed to develop participants' questioning strategies.

In the teaching TMS, the change processes of the participants were examined by analyzing the self-monitoring forms (Appendix 1), field notes, and interviews.

In the teaching RCSS, the self-monitoring forms (Appendix 2) that the participants filled out, field notes and interviews were analyzed, and the change processes of the participants was determined.

In the teaching WS, each week, the participants were given a chemistry topic (e.g., Dalton's Atomic Theory). They were asked to write an article about this given topic. Their change processes were analyzed by examining the writing strategies they used each week. The change processes of participants were examined by analyzing the self-monitoring forms (Appendix 3) and field notes.

In the teaching QS, a discussion environment was created by posing questions, including "What do you understand from asking questions?", "What

kind of questions do you ask?", and "When and why do you ask questions?". The importance of asking questions was then touched upon before explaining the four-week-long implementation. Interesting texts that were capable of being related to daily life were given to the participants each week. For example, a text titled "Apple juice-attention! Patulin inside" was given in the first week, "Chlorofluorocarbons" in the second week, "Chocolate diet?" in the third week, and "Back to recycling" in the last week. The participants were asked to generate questions from these texts, which had been selected from the literature on the basis that they yielded high-level questions (See Kaberman & Dori, 2009b). The questions the participants generated from the texts were scored using the classification developed by Kaberman & Dori (2009b) (Table 4).

Table 4 Scoring Questions Generated from the Texts

Content	Thinking level	Chemistry understanding levels*
Irrelevant to the text (0 point)	Answer is included in the text (0 point)	Not used (0 point)
Directly relevant to a phenomenon in the text (1 point)	Answer is at the level of knowledge and understanding(1 point)	If it includes one level (1 point)
Possible solutions (2 points)	A higher order of thinking process is needed. (2 points)	If it includes two levels (2 points)
		If it includes three levels (3 points)
*Macroscopic, microscopic, symbolic level		

Data Analysis

The descriptive and content analysis methods were used to organize the qualitative data of the study. Data analysis involved 1) data coding, 2) establishing categories, 3) organizing data according to codes and categories, 4) reviewing codes and categories, and 5) interpreting results. Codes and categories were formed for the analysis of the qualitative data in line with the theories in studies on self-regulated learning and strategy instruction. Table 5 shows these codes and categories where it can be seen that the categories included time management strategies, reading comprehension and summarization strategies, writing strategies, questioning strategies, study strategies and metacognitive strategies. During the process of teaching time management strategies and teaching writing strategies, it was determined that the participants used some strategies other than time management strategies and writing strategies. These strategies were handled as study strategies and were examined three sub-categories: rehearsal, elaboration and organizational strategies.

In the process of teaching reading comprehension and summarizing strategies, study strategies were determined as in the others.

However, since these study strategies are directly related to reading comprehension and summarizing strategies, a different study strategies table was not created. Therefore, the strategies determined were explained with a table of reading comprehension and summarizing strategies. In the teaching questioning strategies, questions posed by the participants were scored using a classification developed by Kaberman and Dori (2009b) (Table 4). Therefore, these questions were investigated under the following sub-categories: content, thinking level, and chemistry understanding levels.

The first category, knowledge about cognition included the sub-categories of declarative knowledge, procedural knowledge, and conditional knowledge, while the latter category, the regulation of cognition, included the sub-categories of planning, monitoring, and evaluation. The results obtained were supported with excerpts when necessary.

Table 5 Data Analysis: Emergent Categories and Codes

Time Management Strategies	Reading Comprehension and Summarization Strategies	Writing Strategies	Questioning Strategies	Study Strategies	Metacognitive Strategies
Using the time well Rewarding oneself Removing distractive elements Allocating more time each week	Relating reading text to previous knowledge Finding the main idea Posing questions to oneself Making a summary by underlining important points Skimming over the titles, reading the entire text and summarizing it Making a summary by reading page by page Summarizing part by part Rewriting important points of the text Re-reading Making a summary by underlining important points Blending new content with previous knowledge and writing down what is on the mind Posing questions to oneself Reinforcing by using previous topics Outlining general characteristics of the topic Writing on different pieces of papers and then combining them	Writing after organizing thoughts in the mind. Posing idea-generating questions Reviewing Exemplifying Using visuality (drawing) Posing idea-generating questions Revising Setting up a goal Self-criticizing/ Becoming a self-editor. Listing Expressing by writing a formula	Content Irrelevant to the text Directly relevant to a phenomenon in the text Possible solutions Thinking Level Answer is included in the text Answer is at the level of knowledge and understanding A higher-order of thinking process is needed. Chemistry Understanding Levels Not used It includes one level It includes two levels It includes three levels	Rehearsal Strategies Elaboration Strategies Organizational Strategies	Knowledge about cognition Declarative knowledge Procedural knowledge Conditional knowledge Regulation of cognition Planning Monitoring Evaluation

Results

Results on Teaching Time Management Strategies (TMS)

The strategies that the participants applied in the process of teaching time management strategies were determined by examining the self-monitoring forms, considering the field notes, and analyzing the interviews regarding the strategies that they used while studying quizzes and texts. According to the results in Table 6, the participants did not use any time management strategy in the first week of teaching time management strategies. Starting in

the second week, it was observed that they began to allocate more time for studying so they applied one of the time management strategies; "using the time well". Furthermore, the participants also used other time management strategies such as "rewarding oneself" and "removing distractive elements". In the last week of the implementation, the participants were observed to be using the strategies they had applied in the second week, without adding any new strategies. In addition, it was determined that the number of participants using these time management strategies increased considerably in the last week.

Table 6 Number of Participants using Strategies in the Process of Teaching Time Management Strategies

Time Management Strategies	Number of Participants (N)		
	1st Week	2nd Week	3rd Week
Using the time well	-	3	9
Rewarding oneself	-	2	8
Removing distractive elements	-	2	8
Allocating more time each week	-	3	7

Results on Study Strategies during Teaching Time Management Strategies (TMS)

During the process of teaching time management strategies, it was determined that the participants used some strategies other than time management strategies. These strategies were handled as study strategies and presented in Table 7 under three sub-titles. According to the results in Table 7, the participants used the strategy of "underlining important points" the most during this three-week process, which was followed by other learning strategies. The participants mostly applied rehearsal strategies (underlining important points, reading, and skimming over the titles, etc.) in the first week; however, only one participant used the elaboration strategy (relating content to the previous topic). In the second week, the participants continued to use the first-week strategies but added new strategies as well, like the different time management strategies recommended to them by both the researchers and

their peers. For example, "taking notes on the text", "revising", and "taking notes on a sheet of paper" all of which are rehearsal strategies, were the most used new strategies. "Relating content to the previous topic", "reading aloud", "summarizing", and "self-teaching the topic" were among the other study strategies the participants used. In the second week, only one participant used "breaking content down into pieces" which is an organizational strategy. In the last week of the implementation, it was seen that the strategies used in the second week continued to be used and there was also an increase in the number of participants using these strategies.

Table 7 Number of Participants Using Study Strategies in the Process of Teaching Time Management Strategies

Time Management Strategies	Number of Participants (N)		
	1st Week	2nd Week	3rd Week
Rehearsal Strategies			
Underlining important points	5	8	12
Reading	3	4	5
Skim over titles	3	1	1
Taking notes on the text	-	5	8
Revising	-	4	8
Reading aloud	-	2	2
Taking notes on a sheet of paper	-	4	6
Elaboration Strategies			
Relating content to the previous topic	1	2	3
Summarizing		3	6
Self-teaching the topic	-	2	3
Generating questions	-	1	2
Organizational Strategies			
Breaking content down into pieces	-	1	1

Results on Teaching Reading Comprehension and Summarization Strategies (RCSS)

The strategies that the participants applied in

the process of teaching "reading comprehension and summarization strategies" were determined by examining the self-monitoring forms, and considering field notes and analyzing the interviews. The participants graded their summaries by referring to the self-monitoring forms they were responsible for filling out each week. One of the researchers also graded these summaries. This process was repeated each week, and the reading comprehension and summarization strategies that the participants used in this process were determined. As the participants were provided with individual feedback, they had the chance to monitor their performances by comparing them with previous performances as the weeks progressed. They started to use new strategies as needed.

Table 8 shows the results on various strategies that the participants used in the process of teaching RCSS. All of the strategies determined in this process were directly related to reading comprehension and summarization strategies. For this reason, these strategies were handled as "reading comprehension and summarization strategies" without the need for a "study strategies table" and were examined under three sub-titles.

As Table 8 indicates, in the first week of teaching RCSS, the pre-service teachers used the strategy of "making a summary by underlining important points" the most. In the second week, the participants applied the new strategies of "rewriting important points of the text", "blending new content with previous knowledge and writing down what is on the mind", and "re-reading". Moreover, the participants were found to add strategies such as "posing questions to oneself", "reinforcing by using previous topics" and "outlining the general characteristics of the topic", to the strategies they used in the first two weeks. In addition, the first-week strategies were mostly rehearsal strategies, while the elaboration and organizational strategies started to be preferred starting from the second week. In the third week, elaboration (relating reading text to previous knowledge) and organizational strategies (writing on different pieces of papers and then combining them), which had never been used in the previous weeks, started to be used. In the fourth and final week, the participants did not use a new strategy, but there was an increase in the number of participants using the strategies identified in the first three weeks.

All in all, it can be said that the strategies that the participants used in the teaching RCSS were quite diversified. The RCSS that the participants used in the first week tended to be only rehearsal strategies, with elaboration and organizational strategies being added to them in the second week. The participants then added new strategies to their RCSS in the third week. Although they did not use a new strategy in the fourth week, the elaboration and organizational strategies became more diversified, and there was an increase in the number of participants using these strategies.

Table 8 Number of Participants Using Strategies Determined in the Process of Teaching Reading Comprehension and Summarization Strategies

Reading Comprehension and Summarization Strategies	Number of Participants (N)			
	1st Week	2nd Week	3rd Week	4th Week
Rehearsal Strategies				
Making a summary by underlining important points	10	9	10	11
Skimming over the titles, reading the entire text and summarizing it	5	3	3	8
Making a summary by reading page by page	4	4	2	3
Summarizing part by part	1	1		
Rewriting important points of the text	-	3	5	7
Re-reading	-	8	5	7
Elaboration Strategies				
Finding the main idea	2	5	4	7

Blending new content with previous knowledge and writing down what is on the mind	-	4	1	6
Posing questions to oneself	-	4	4	5
Relating reading text to previous knowledge	-	-	3	8
Reinforcing by using previous topics	-	4	6	7
Organizational Strategies				
Outlining general characteristics of the topic	-	3	4	8
Writing on different pieces of papers and then combining them	-	-	4	5

Results on Teaching Writing Strategies (WS)

Results on the types of strategies the participants used in the process of teaching writing strategies were presented in Table 9. The table shows that no writing strategy was encountered in the first week, whereas various writing strategies were used in the second week (writing after organizing thoughts in the mind, setting up a goal, self-criticizing/becoming a self-editor, drafting, etc.). No new writing strategy was detected in the third week. Nevertheless, there was an increase in the number of participants who continued to use previous strategies.

Table 9 shows how the used WS of the participants changed week by week. The following can be said about the individual changes that the participants underwent: according to the results on the implementations regarding writing strategies, writing activities varied in many aspects. During the implementation, some of the participants wrote quite superficial and deficient texts, while others wrote in a more explicit and clear manner. For example, Georgia's first-week writing activity included incoherent, inverted sentences with a vague aim, while Venessa's first-week writing activity was more focused and explanatory. In the following weeks of the teaching of writing strategies, it was observed that the participants added new strategies to their current writing strategies. Considering Georgia's improvement process, her unfocused writing in the first week, which included inverted sentences with vague aims, gave way in the second week to better organized writing that clearly had a main idea and included more sufficient knowledge in terms of content. By the final week, she was found to have used the strategies of posing idea-generating questions, setting up a goal and revising. Regarding Brenda's improvement process, in the writing activity of the first week, wrote a superficial article. In the writing activity for the second week, she started her writing out by posing a question, which means she used the strategy of posing idea-generating questions. She failed to demonstrate improvement in the third week compared to the second week. Moreover, she did not use writing strategy. However, she expressed the contribution of the writing activities in these words: "I can say this, I learned how to conduct research; I tried to be attentive to writing more regularly".

Table 9 Number of Participants Using Strategies Determined in the Process of Teaching Writing Strategies

Writing Strategies	Number of Participants (N)		
	1st Week	2nd Week	3rd Week
Writing after organizing thoughts in the mind.	-	5	8
Posing idea-generating questions	-	6	8
Reviewing	-	4	7
Drafting	-	5	7
Setting up a goal	-	6	7
Self-criticizing/ Becoming a self-editor.	-	3	5
Expressing by writing a formula	-	4	8

Results on Study Strategies during Teaching Writing Strategies (WS)

Table 10 shows that the participants used rehearsal and elaboration strategies including "relating content to previous topics", "underlining" and "taking notes on the text", in the first week of teaching writing strategies. Moreover, in the first week participants

used two organizational strategies (breaking content down to pieces and listing strategies). New rehearsal, elaboration and organizational strategies were added to these in the second week. In the last week, more participants continued to use the first- and second-week strategies.

Table 10 Number of Participants Using Study Strategies in the Process of Teaching Writing Strategies

Study Strategies	Number of Participants (N)		
	1st Week	2nd Week	3rd Week
Rehearsal Strategies			
Underlining	2	5	7
Re-reading	-	2	5
Taking notes on the text	2	5	5
Elaboration Strategies			
Relating content to previous topics	3	5	8
Self-teaching	-	3	6
Revising	-	5	9
Exemplifying	-	4	8
Organizational Strategies			
Breaking content down to pieces	2	5	7
Listing	1	4	8
Using visuality (drawing)	-	1	2

Results on Teaching Questioning Strategies (QS)

The questions posed by the participants for four weeks were analyzed according to the classification in Table 4. One of the researchers and an expert on chemistry education evaluated these questions. The disagreements between the researcher's and the expert's scoring of the participants' questions were resolved through discussions until an agreement was reached.

The percentage distribution of the questions posed by the participants regarding content, thinking level, and chemistry understanding levels is given in Table 11, and separately explained below.

Content: The number of questions evaluated as "irrelevant to the text" increased after the first week, but considerably decreased after the third week, when the participants' questions were analyzed regarding content dimension. The questions were evaluated as "directly relevant to a phenomenon in the text" decreased. The percentage of the questions under the category of "possible solutions" had approximately the same value for the first three weeks and increased to 24% in the last week. Considering the data obtained in the four-week period, the majority of the questions posed each week were directly relevant to a phenomenon in the text, and the increase in the percentage of the questions that might create a possible solution was particularly striking. For example, in the first two weeks, the questions that Brenda formed, when they were analyzed from the perspective of "content" dimension, were "directly relevant to a phenomenon in the text". As of the third week, on the other hand, she started to prepare some questions which could be considered as "possible solutions", in addition to the questions "directly relevant to a phenomenon in the text". In the last week similar to her performance in the third week, she prepared questions that were in the categories of both "directly relevant to a phenomenon in the text" and "possible solutions". Considering Sharon' questions, another participant, she started to ask questions in the category of "possible solutions" in the third week. In looking at the questions by Kate and Jessica, all of the questions they formed in the first three weeks fell under the category of "directly relevant to a phenomenon in the text", but in the last week, they added some questions which could fall under the category of "possible solution".

Thinking Level: The majority of the questions were at the level of knowledge and understanding when the participants' questions were analyzed in terms of "thinking level". However, the increase in the percentage of questions requiring a higher order thinking process in the third and fourth week is rather important. For example, the questions formed by Bella, Jessica, and Jasmin were in line with the general tendency of the "thinking level" dimension. While the questions these participants formed in the first weeks fell under the first two categories, they started to form questions in the category of "a higher

order of thinking process is needed" as of the third week. Caroline and Ruth formed questions from each category each week, and an increase was observed in the number of questions that fell under the category of "a higher order of thinking process is needed" in the third and fourth weeks.

Chemistry understanding Levels: Considering the participants' questions in terms of "chemistry understanding levels", the questions that included a single level in the answer were mostly encountered in Table 11. During the four weeks, no regular increase or decrease was observed.

For example, even though Brenda and Jessica were preparing questions that included one dimension of chemistry and three dimensions of chemistry as of the first week, a decrease was seen in the number of Bella's and Robert's questions involving the dimensions of chemistry as the weeks progressed.

Table 11 Percentage Distribution of the Questions Posed by Participants Regarding Content, Thinking Level, and Chemistry Understanding Levels

Dimensions	Orders	Exemplary questions from the texts	Percentage distribution (%)			
			1st Week	2nd Week	3rd Week	4th Week
Content	Irrelevant to the text	Are the participants in the study the ones who had heart attacks?	0	2	16	3
	Directly relevant to a phenomenon in the text	Can juice be alkaline?	90	88	75	73
	Possible solutions	The ulcer threat is based on which characteristic of the matter?	10	10	9	24
Thinking Level	Answer is included in the text	How do the advancements in technology affect the consumption of resources?	27	65	9	14
	Answer is at the level of knowledge and understanding	What is the effect of an alkaline environment on patulin?	56	19	57	51
	A higher order of thinking process is needed.	How can you cope with other diseases stemming from weight gain by eating chocolate?	17	17	34	35
	Not used	Who was this research planned by?	10	2	29	22
Chemistry Understanding Levels	The answer includes one level	Which substances can be recycled?	58	73	62	57
	The answer includes two levels	Why does CFC continue to be used even though it is known to be harmful?	20	19	7	11
	The answer includes three levels	What property of carbon affects the stability of patulin?	12	6	2	11

Results on Metacognitive Strategies

The metacognitive strategies used by the pre-service chemistry teachers during the Basic Learning Strategies Instruction (BLSI) were examined. It would not be correct to say that these strategies were identified in all of the participants. Five of the participants failed to completely continue the implementations, some of them did not complete

certain activities, and others did not participate in in-class discussions, which meant that the follow-up of these strategies could not be done for these participants.

Knowledge about Cognition

The participants' statements implied that they applied metacognitive strategies, considering that they were aware of their own cognitive processes; thus, they had knowledge about cognition. Since they had knowledge about the strategies they used, they may possess declarative knowledge, which is one of the sub-components of knowledge about cognition.

Meghan: "I completed the topic by finding and remembering the form for the parts that I learned before but could not remember in the topic from other sources".

Meghan expressed the difficulty she encountered and formulated the ways to overcome this difficulty. This behavior was related to when and how to used her cognitive activity and it demonstrated that she had conditional knowledge, which is one of the sub-components of knowledge about cognition.

Georgia: "I noticed that when I exchanged ideas with several friends within group study, I built more logical sentences and generated more solid questions."

Georgia expressed that she had awareness about the situations in which she could generate better questions and she implied that she had conditional knowledge.

Dillon: "We filled out charts about how we study. I used to study whenever I felt like it. I did not have a concept like time. Thanks to all these practices, I started to develop strategies on my own. I developed strategies, such as, if I work like this for this course, I will be successful, or how much time do I need to allocate? Is my method of studying correct? I was able to see them".

Dillon showed that she had procedural knowledge which is one of the knowledge about cognition components underlining that she developed different strategies to overcome the problem.

Regulation of Cognition

Meghan: "I used to study randomly. In fact, I

never realized it exactly, but I studied in any way I liked for that particular moment. Thanks to these practices, I figured out how I understand. I said to myself that I can understand it better when I do this in this way, and so I planned to always continue to study that topic in this better way. I used to start studying without first figuring out how I would go about it. I used to read, and I continue to do so, but I do it in a better way now. Now, I figured out how I understand better. I also used to study by underlining but did not know that this was very good for me. Now, I am comfortably aware of this. I can say that this is good for me. Now, I know how to study well".

Meghan expressed that she was aware of how she understood better and continued her studies in this way, which implied that she used the planning strategy, one of the sub-components of regulation of cognition in metacognition.

Kelly: "These practices, which we carried out for three weeks, were quite useful for me, as they helped me to build the topic on a solid base, and they led to changes in my study habits. I think that change is good. I am able to control myself. Also, since we have a better background on these topics, I think that we study more. This was not the case for the topic of energy, however".

Kelly stated that she could control herself through these applications. It showed that she used the monitoring strategy.

Meghan's expression "I revised and checked to see if there was any point that I overlooked" highlighted her instant awareness of her comprehension. This behavior by Meghan implied that she controlled her own cognitive activities, which indicated that she used the monitoring strategy, one of the sub-components of regulation of cognition in metacognition.

Bella: "I realized that it is not good for me to study in complex, crowded environments; I tried to arrange a more organized study environment".

Bella indicated the change in her study environment. This behavior exemplifies the control over the change she made in the process of reaching the goal, which implies that she used the monitoring strategy, one of the sub-components of regulation of cognition in metacognition. Two more examples of participants using the monitoring strategy are given below.

Sharon: "I realized that through summarizing, I was able to pick up on knowledge that I had not previously noticed. I was organizing once again, and writing and making drafts for myself".

Meghan: "I learned that I did not know how to summarize. I thought that I was summarizing by simply underlining. Then, I realized that summarizing involved transforming text into a form that I could understand".

Sophie's statement, "I did not allocate sufficient time in the second week, and the result was bad. However, I allocated a lot of time in the last week. The topic on energy was difficult though. I am too focused to details, and this caused me to fail" and Jessica's statement, "I just read for the first quiz, but in the second quiz I made a summary. This helped a lot" showed that they reached a conclusion on their own performances and strategies, which implies that Sophie and Jessica both used the evaluation strategy.

Discussion

In the literature related to the development of self-regulated learning skills, a number of studies conducted either did not focus on a specific discipline (Simpson et al., 1997) or were conducted with a focus on a particular discipline (Kadioglu-Akbulut, & Uzuntiryaki-Kondakci, 2021; Perels, Dignath, & Schmitz, 2009; Pressley & Woloshyn, 1995). The present study was conducted by focusing on the chemistry discipline in General Chemistry I-II, and Inorganic Chemistry I-II courses. Thus, the activities prepared within the scope of this study provided the participants to reinforce their chemistry content knowledge, and awareness that the learning strategies used can be applied to different topics. The fact that this study was carried out in such a way as to be integrated into the chemistry education program was one of the strengths of this study. This manner in which the study was performed was similar to the way other studies in the literature were conducted (Hattie, Biggs, & Purdie, 1996; Horn, 2003; Perels, Dignath, & Schmitz, 2009; Quince, 2013). Another highlighted feature of SLSD studies in the literature is that the application period should be kept longer (Boekaerts, 1999; Ragosta, 2010). Therefore, the long-term (two years) nature of the study qualifies as another strength of this present study.

The practices of the 1st and 2nd parts of the Basic Learning Strategies Instruction (BLSI), which were either three or four weeks long, were carried out in loops, as indicated in the methodology section, where chemistry topics were assigned as homework to the participants. This homework was discussed each week in the classroom, feedback was provided, quizzes were made and evaluated, and in-class discussions were performed on the strategies that were recommended and used (Fig. 2). The aim of repeating these loops for at least three weeks was to enable the participants to have longer-term experiences, whereby they would be equipped to set up a goal for homework, adopt appropriate learning strategies, maintain their motivation, and monitor and evaluate their improvement. Self-monitoring forms which were formed in line with the basic learning strategies suggested by Zimmerman, Bonner, and Kovach (1996), was used in the implementations. The results obtained by the evaluation of the self-monitoring forms indicated that the implementations were effective in fostering self-regulated learning skills in the participants. Similar results were found from the other studies in the literature that used the aforementioned forms (Bembenutty & White, 2013; Hancock, 2002; Ramdass & Zimmerman, 2011; Stoeger & Ziegler, 2008; Trautwein & Koller, 2003).

Discussion on Teaching Time Management Strategies (TMS)

The participants were provided the opportunity to gain awareness of their learning processes with the activities conducted each week because they recorded the time they spent, and how, when, and with whom they studied when working on the homework text given each week. As a result of the study, they related their scores on quizzes to their study records. In other words, the participants learned how to engage in self-monitoring. They were offered the opportunity to correct their mistakes and eliminate their deficiencies.

The feedback from the researchers provided an improvement in the participants' motivation and development in their self-efficacies. The learners' were allowed to monitor their study periods in this way enabled them to personally see how much time they had spent on studying. This motivated them

to revise their habits of studying and adopt regular studying habits (Puspitasari, 2012), as making plans and regulating the time spent on studying helped them to realize their own learning goals (Dabbagh & Kitsantas, 2005; Lynch & Dembo, 2004).

The participants increased the amount of time that they spent studying and added new strategies to the ones that they were already using to improve their quiz scores, which implies that they controlled and regulated their learning processes. The participants, who in the first week studied by reading and underlining only, were able to note the effect of using new strategies, such as taking notes on a sheet of paper, summarizing, revising, rewarding oneself, and removing distractive elements, on their performances.

The participants' strategies applied in the process of teaching time management strategies generally included study strategies, while strategies related to "time management" were less often encountered. The fact that this occurred very early in the study and that the participants were not yet familiar with the process may be listed among the reasons for this situation. An improvement in learning strategies was expected in all of the participants however it was not fully met. This may be attributed the fact that the pre-service teachers found it difficult, at this stage, to add new strategies to the ones that they were familiar with, because adult learners find it quite hard to change their academic habits and they are rather resistant to changes when compared to younger learners (Chan & Bauer, 2016; Dembo & Seli, 2004; Ragosta, 2010). Nevertheless, strategies such as monitoring and control were observed to be used by several participants, which showed a contribution the strategy instruction performed had to the self-regulated learning.

The participants had learned to monitor themselves (self-monitoring) through examining management of distractive elements and arrangement of a suitable place to do homework, which were suggested by Trautwein and Koller (2003) in addition to their strategy of using time, which is a part of teaching time management strategies. Thus, they had opportunity to monitor, control and regulate their own learning processes. Although there are many reasons to give homework, in this study, homework was assigned

for the purpose of raising the participants' awareness about the study strategies, which in effect contributed to the improvement of their metacognitive strategies. Excerpts of the participants' opinions on this issue are given in the "results on metacognitive strategies" section.

Discussion on Teaching Reading Comprehension and Summarization Strategies (RCSS)

The reading comprehension and summarization strategies (RCSS) applied by the participants at the end of teaching RCSS were similar to the strategies the learners used in the learning processes and reading comprehension, as determined by Carrell, Gajdusek and Wise (1998). Some of these strategies included determining the main idea, re-reading, and stimulating prior knowledge. The reading comprehension strategies developed by Pressley (2002), which included re-reading, taking notes, rewriting important knowledge, identifying topic sentences, combining ideas to reach the main idea, posing questions to oneself, and outlining were similar to the reading comprehension strategies applied in the present study.

In another study that aimed to promote learners' reading comprehension by performing explicit instruction, an increase in the learners' use of these strategies was found (Khezrlou, 2012). One point to be highlighted is that the pre-service teachers had more difficulties in teaching "reading comprehension and summarization strategies" when compared to teaching time management strategies because it was more time-consuming for the participants to read and make a summary of the chemistry text given to them. The participants expressed this difficulty but still tried to participate in the implementations. The summaries and self-monitoring forms completed by the participants who participated in the implementations on a regular basis were examined and the interviews conducted with them were analyzed. Therefore, the results showed an improvement in some participants. It was quite clearly seen that the RCCS the participants used grew more diversified over the course of the four-week practices, and that the number of participants using these strategies increased. Furthermore, strategies related to the metacognition dimension of

self-regulated learning were seen to be applied by the participants, in performing the RCSS.

According to study by Kolić-Vrhovec, Bajšanski and Rončević Zubković (2011), on university students with regard to their reading comprehension of scientific texts in terms of various variables, they found that making summaries helped them to engage in self-monitoring. Kolić-Vrhovec et al., (2011) stated that while doing self-monitoring, the students could be distracted by the comprehension of text, and that this may enable them to develop strategies to overcome learner's deficiencies.

Discussion on Teaching Writing Strategies (WS)

Self-regulation and the use of different strategies are important components of learning in all academic discipline. These components are thought to be rather powerful catalysts in supporting students' writing performances (Harris, Santangelo, & Graham, 2010). A study by Fahim and Rajabi (2015) on the effect of self-regulated strategy instruction on students' writing performance, provided 30 students attending English course with 10 lessons on self-regulated strategy improvement teaching. Their study focused on skills believed to affect students' writing performances, such as planning, setting up goals, monitoring and evaluation. With this self-regulated strategy improvement teaching, they detected improvements in the students' writing performances and motivation. Moreover, Graham and Harris (2003) showed that self-regulated strategy improvement teaching enhances students' writing skills. The results obtained in these aforementioned studies were in parallel with the results of teaching writing strategies in the present study.

Discussion on Teaching Questioning Strategies (QS)

In the teaching questioning strategies, the participants generated questions from interesting texts for a period of four weeks. These questions were analyzed using a classification tool (See Table 4). This classification tool helped us to determine the complexity of each question. The questions were expected to grow in complexity in terms of content, thinking level, and chemistry understanding levels, as the weeks progressed. With the teaching questioning

strategies, this expectation was met. For example, most of the questions", when investigated in terms of content, formed were in the category of "directly relevant to a phenomenon in the text. In addition, as of the first weeks, questions that could be considered to be under the category of "possible solutions" were asked, and the number of such questions increased considerably in the last week.

The thinking level of the student generated questions was another part of the question classification tool. Most of the questions the participants prepared were at the level of knowledge and comprehension. However, in the last weeks, they also started to prepare questions that required a higher level of thinking than knowledge and comprehension. Questioning is highly related to higher order thinking. It is an important skill for improving learning because it plays a key role in fostering awareness and understanding in the learners and facilitating their engagement in self-monitoring (Taboada & Guthrie, 2006). Three levels of chemistry understanding are crucial for making sense of chemistry. When the questions of the participants were examined, no regular increase or decrease was found in this context. The participants prepared questions that mostly involved one level of chemistry understanding. The participants had trouble understanding this part during the instruction on questioning strategies. Furthermore, they had difficulty in making decisions when developing their questions from the perspective of chemistry understanding levels, which could stem from the fact that the knowledge structure of chemistry contains abstract concepts that are difficult to comprehend. Questioning was quite effective in the improvement of students' scientific and critical thinking and therefore are rather important in science education (Santoso & Yuanita, 2017).

In carrying out the "questioning strategies" practices, the participants were provided the opportunity to recognize the importance of asking questions, and they gained an awareness of their understanding and comprehension. The importance of these questioning skills is supported with the opinions expressed by the participants.

By encouraging the students to ask questions in the classroom, the improvement of questioning

strategies can be realized, and students can be equipped with the skill to control their own learning. A study by Kaberman and Dori (2009b) on questioning stated that learners who were able to apply the questioning strategies were aware of their own cognitive processes and they were able to self-regulate their learning.

Discussion on Metacognitive Strategies

In this study, the strategy instruction was performed. It is possible to say that strategy instruction practices also activated pre-service teachers' use of metacognitive strategies. Although it was desired to develop the cognition component of self-regulated learning in the pre-service chemistry teachers by strategy instruction, the practices also affected the metacognition component. Three basic components must interact in self-regulated learning: cognition, metacognition, and motivation (Ali, Siddiqui, & Tatlah, 2020; Schraw, Crippen, & Hartley, 2006; Tarricone, 2011). Among these, metacognition is the strategies that are necessary for the learner to plan, monitor and evaluate their own cognitive processes (Efklides & Misailidi, 2010). The self-regulated learners set goals for themselves, choose strategies suitable for their goals, implement them, monitor and evaluate their performance (Dinsmore, Alexander, & Loughlin, 2008; Stanton, Sebesta, & Dunlosky, 2021). Considering the above-described components of metacognition, it is inevitable that these metacognitive processes are active in a self-regulated learner. The number of studies on metacognition is gradually increasing. The reason for this is that metacognition is positively related to many academic variables and metacognitive strategies can be taught to learners (Broadbent & Poon, 2015; Chi & Wylie, 2014; Jansen et al., 2019; Kramarski & Mevarech, 2003).

In this study, while trying to improve the strategy use of the participants in the BLSI process, the reflection of this situation on the use of metacognitive strategies was also examined. These strategies could not be detected in the students who did not regularly participate in BLSI practices. From the statements of the participants attending BLSI practices, it was concluded that they were aware of their own cognitive processes, that is, they had the

"knowledge about cognition" strategy, which is the sub-component of metacognition. In addition, it was determined from the statements of the participants that they used strategies to supervise and control their own learning, and it was concluded that they had the "regulation of cognition" strategy, which is another sub-component of metacognition.

While students are preparing for a quiz, they can use metacognition to gain insight into their learning. Students can think about how they will be tested, set goals for their learning, and come up with a plan to achieve their goals (Stanton, Sebesta, & Dunlosky, 2021). In this study, participants took quizzes every week in teaching TMS and RCCS (See Figure 2). It can be thought that this process may have positively affected their use of metacognitive strategies. This may suggest that the participants who got used to this process while teaching "time management strategies" and "reading comprehension and summarization strategies" also applied the metacognitive strategies in the other parts of their studies. It is possible to say that not only quizzes, but also self-monitoring forms, encourage participants to use metacognitive strategies (Zimmerman, Bonner, & Kovach, 1996). Also, effective questions can be a way to engage students in the learning process and enable them to take responsibility for their own learning (Nappi, 2017). Thanks to the questions asked by the participants during the teaching of questioning strategies, they were involved in the learning process and this enabled them to take charge of their own learning.

Conclusion

Based on the results of this study, it can be concluded that strategy instruction affects pre-service teachers' strategy use. In addition, these practices provided them metacognitive awareness. As a result of these applications, it is possible to say that pre-service chemistry teachers have become more self-directed learners by being aware of their own learning processes. Therefore, this study introduced an exemplary plan regarding how to provide self-regulated learning in university students. The participants mostly applied rehearsal strategies while they rarely used the organizational strategies. It was difficult for them to add new strategies to their current ones.

It can be said that changing the undergraduate students' learning strategies was difficult. Undergraduate students can often say: "Why would I change my strategy?" and "I enrolled in university so my strategy must have been good". It is thought that this way of thinking may prevent them from adopting new strategies and using them. Considering that time and repetition are important factors in students' strategy change, it is possible to say that this study was spread over a very long period of time and that repeated practices were performed in this process. However, long-term practices may cause students to become bored, which might result in a decrease in their motivation. In case of such incidents, individual and collective interviews were made and they were motivated. Although the participants resisted making changes to their current strategies, the percentage of questions that required higher order thinking was found to have increased considerably. Although the study was carried out in line with the contents of the chemistry courses, the inclusion of intangible concepts that made it difficult to understand chemistry was considered as one the reasons for this ambivalent change. Furthermore, carrying out strategy instruction integrated into an academic content implied that the pre-service teachers had become able to use the strategies that they learned to other topics related to their domain.

Limitations, and Suggestions for Future Research

Since many of the students stated that they use multiple strategies at the same time, each strategy needs to be evaluated independently to find out what is important for their academic performance (Dunlosky, et al., 1993). During the BLSI practices, it was aimed to enable the participants to add new strategies to their own strategies. How each strategy they used affected their performance was not examined. Instead, when reading, summarizing, asking questions, and so on, which strategies they used was determined and the changes in their performance during the implementation process were examined. This can be expressed as a limitation of the study, as it did not examine how each strategy affected performance. In future research, it can be investigated how each strategy affects performance. During Questioning Strategies practices, several participants stated that they found some texts more interesting and enjoyable. Therefore, the change in level of participants' questions may be reflect some participants' relative interest in each text. This can be considered as a limitation of teaching QS.

The findings of this study suggest a need to develop preservice teachers' self-regulation during their training programs. In other words, chemistry education researchers can train pre-service teachers about self-regulated learning and develop classroom tasks accordingly. Teachers, thus, may benefit from this study when designing courses to support the use of different learning strategies.

This study included only 18 pre-service chemistry teachers. Considering the requirements of the implementation, this study can be performed with more participants in more diverse chemistry courses to obtain more comprehensive and generalizable results.

Acknowledgement

Appendix 1 Time Management Strategies Self-Monitoring Form

Day	Homework	Start Time	Finish Time	Study Situation			Self-Efficacy
				Where?	With Whom?	Procrastination / Distractions	

Appendix 2 Reading Comprehension and Summarization Strategies Self-monitoring Form

Date	Time Spent Studying	Page Number	Number of Main Ideas Summarized	Number of Points Highlighted			Self-Efficacy

Appendix 3 Writing Strategies Self-monitoring Form

	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.	Wed.
Article Topic: "Dalton's Atomic Theory"							
How much time did I spend on the article specified?							
What should be included in my article? …………… ……………							
My self-efficacy score (out of 10)					NS	S	AS
Explanation: Not Sure=NS, Sure =S, Absolutely Sure =AS							

References

Ali, M. S. Z., Siddiqui, G. K., & Tatlah, I. A. (2020). Understanding the effect of the metacognitive skills on pupil teachers' task performance: A mixed-methods inquiry. *Pakistan Journal of the Society, education and language*, 2523-1227.

Altun S., (2005), *Öğrencilerin öz düzenlemeye dayalı öğrenme stratejilerinin ve öz yeterlik algılarının öğrenme stilleri ve cinsiyete göre matematik başarısını yordama gücü*, Doctoral dissertation, Istanbul:Yıldız Teknik University.

Atasoy B., (2004), *Temel kimya kavramları*, [Title in English: Basic Chemical Concepts]. Asil Yayın Dağıtım.

Bembenutty, H., & White, M. C. (2013). Academic performance and satisfaction with homework completion among college students. *Learning and Individual differences, 24*, 83-88.

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International journal of educational research, 31*(6), 445-457.

Boekaerts M., Pintrich P. R. & Zeidner M. (Eds.), (2000), *Handbook of self-regulation*, p13-39. Elsevier.

Broadbent, J., & Poon, W. L. (2015). Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. *The Internet and Higher Education, 27*, 1-13.

Brown A. (1987). *Metacognition, executive control, self-regulation, and other more mysterious mechanisms, Metacognition, motivation, and understanding*. Lawrence Erlbaum Associates Publishers.

Carrell, P. L., Gajdusek, L., & Wise, T. (1998). Metacognition and EFL/ESL reading. I*nstructional science, 26*(1), 97-112.

Chan, J. Y., & Bauer, C. F. (2016). Learning and studying strategies used by general chemistry students with different affective characteristics. *Chemistry Education Research and Practice, 17*(4), 675-684.

Chi, M. T., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational psychologist, 49*(4), 219-243.

Dabbagh, N., & Kitsantas, A. (2005). Using web-based pedagogical tools as scaffolds for self-regulated learning. *Instructional Science, 33*(5), 513-540.

Dembo, M. H., & Seli, H. P. (2004). Students' Resistance to Change in Learning Strategies Courses. *Journal of developmental education, 27*(3), 2-11.

Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and learning, 3*(3), 231-264.

Dignath-van Ewijk, C., & Van der Werf, G. (2012). What teachers think about self-regulated learning: Investigating teacher beliefs and teacher behavior of enhancing students' self-regulation. *Education Research International*, 2012.

Dinsmore, D. L., Alexander, P. A., & Loughlin, S. M. (2008). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. *Educational psychology review, 20*(4), 391-409.

Donker, A. S., De Boer, H., Kostons, D., Van Ewijk, C. D., & van der Werf, M. P. (2014). Effectiveness of learning strategy instruction on academic performance: A meta-analysis. *Educational Research Review, 11*, 1-26.

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the public interest, 14*(1), 4-58.

Efklides, A., & Misailidi, P. (2010). *Introduction: The present and the future in metacognition.* In Trends and prospects in metacognition research (pp. 1-18). Springer, Boston, MA.

Fahim M., & Rajabi S. (2015). Applying self-regulated strategy development model of instruction to teach writing skill: Effects on writing performance and writing motivation of EFL learners. *International Journal of Research Studies in Education, 4*(2), 29-42.

Foerst, N. M., Klug, J., Jöstl, G., Spiel, C., & Schober, B. (2017). Knowledge vs. action: discrepancies in university students' knowledge about and self-reported use of self-regulated learning strategies. *Frontiers in psychology, 8*, 1288.

Fraenkel, J. R., Wallen, N. E. (2006). *How to design and evaluate research in education* (6th eds.). New York: McGraw-Hill.

Garner, R. (1990). When children and adults do not use learning strategies: Toward a theory of settings. *Review of educational research, 60*(4), 517-529.

Graham S., & Harris K. R. (2003). Students with learning disabilities and the process of writing: A meta-analysis of SRSD studies, in H. L. Swanson, K. R. Harris and S. Graham (Eds.), Handbook of learning disabilities (pp. 323-344). New York: Guilford Press,.

Gurung, R. A., & Burns, K. (2019). Putting evidence-based claims to the test: A multi-site classroom study of retrieval practice and spaced practice. *Applied Cognitive Psychology, 33*(5), 732-743.

Hancock, D. R. (2002). Influencing graduate students' classroom achievement, homework habits and motivation to learn with verbal praise. *Educational Research, 44*(1), 83-95.

Harris, K. R., Santangelo, T., & Graham, S. (2010). Metacognition and strategies instruction in writing. *Metacognition, strategy use, and instruction*, 226-256.

Hattie, J., Biggs, J., & Purdie, N. (1996). Effects of learning skills interventions on student learning: A meta-analysis. *Review of educational research, 66*(2), 99-136.

Hofer B. K., Yu S. L., & Pintrich, P. R. (1998). Teaching college students to be self-regulated learners, in D. H. Schunk and B. J. Zimmerman (Eds.), Self-regulated learning: from teaching to relf-reflective practice (pp. 57-85). New York: Guilford.

Horn S. (2003). *Teacher facilitation of self-regulated reading in ninth grade English, Doctoral dissertation*, The University of North Carolina Greensboro.

Jansen, R. S., Van Leeuwen, A., Janssen, J., Jak, S., & Kester, L. (2019). Self-regulated learning partially mediates the effect of self-regulated learning interventions on achievement in higher education: A meta-analysis. *Educational Research Review, 28*, 100292.

Kaberman, Z., & Dori, Y. J. (2009). Question posing, inquiry, and modeling skills of chemistry students in the case-based computerized laboratory environment. *International Journal of Science and Mathematics Education, 7*(3), 597-625.

Kaberman, Z., & Dori, Y. J. (2009). Metacognition in chemical education: Question posing in the case-based computerized learning *environment. Instructional Science, 37*(5), 403-436.

Kadioglu-Akbulut, C., & Uzuntiryaki-Kondakci, E. (2021). Implementation of self-regulatory instruction to promote students' achievement and learning strategies in the high school

chemistry classroom. *Chemistry Education Research and Practice, 22*(1), 12-29.

Khezrlou S., (2012), Cognitive strategy training: improving reading comprehension in the language classroom. *Journal of Social Sciences and Humanities of Shiraz University, 30*(4), 77-98.

Kistner S., Otto B., Büttner G., Rakoczy K., & Klieme E. (2015). Teaching learning strategies: The role of instructional context and teacher beliefs, *Journal for Educational Research Online , 7*(1), 174.

Kistner, S., Rakoczy, K., Otto, B., Dignath-van Ewijk, C., Büttner, G., & Klieme, E. (2010). Promotion of self-regulated learning in classrooms: Investigating frequency, quality, and consequences for student performance. *Metacognition and learning, 5*(2), 157-171.

Kolić-Vrhovec, S., Bajšanski, I., & Rončević Zubković, B. (2011). The role of reading strategies in scientific text comprehension and academic achievement of university students. *Review of psychology, 18*(2), 81-90.

Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and metacognitive training. *American educational research journal, 40*(1), 281-310.

Lynch, R., & Dembo, M. (2004). The relationship between self-regulation and online learning in a blended learning context. *International Review of Research in Open and Distributed Learning, 5*(2), 1-16.

Ministry of National Education, (2018), Ortaöğretim kimya dersi öğretim programı (9, 10, 11, 12. sınıflar), [Title in English: Secondary chemistry curriculum (9th, 10th, 11th, 12th grades)] retrieved from http://mufredat.meb. gov.tr/ProgramDetay.aspx?PID=350.

Muteti, C. Z., Zarraga, C., Jacob, B. I., Mwarumba, T. M., Nkhata, D. B., Mwavita, M., ... & Mutambuki, J. M. (2021). I realized what I was doing was not working: The influence of explicit teaching of metacognition on students' study strategies in a general chemistry I course. *Chemistry Education Research and Practice, 22*(1), 122-135.

Nappi, J. S. (2017). The importance of questioning in developing critical thinking skills. *Delta Kappa Gamma Bulletin, 84*(1), 30-41.

Nilson, L. (2013). What is self-regulated learning and how does it enhance learning. Creating Self-regulated Learners: Strategies to Strengthen Students, Self-Awareness and Learning Skills (1-22): Stylus Publishing, LLC.

Otto, B. (2010). How can motivated self-regulated learning be improved. International perspectives on applying self-regulated learning in different settings, 183-204.

Paris, S. G., & Winograd, P. (1990). Promoting metacognition and motivation of exceptional children. *Remedial and special Education, 11*(6), 7-15.

Perels, F., Dignath, C., & Schmitz, B. (2009). Is it possible to improve mathematical achievement by means of self-regulation strategies? Evaluation of an intervention in regular math classes. *European Journal of Psychology of Education, 24*(1), 17-31.

Pressley M. (2002). Metacognition and self-regulated comprehension. In A. Farstrup & S. J. Samuels (Eds.), What research has to say about reading instruction (pp. 184-200) Newark, De: International Reading Association.

Pressley M., & Woloshyn V. (1995). Cognitive strategy instruction that really improves childrens' academic performance. Cambridge, MA: Brookline.

Puspitasari, K. (2012). *The effects of learning strategy intervention and study time management intervention on students' self-regulated learning, achievement, and course completion in a distance education learning environment.* The Florida State University.

Quince, B. C. R. (2013). The effects of self-regulated learning strategy instruction and structured-diary use on students' self-regulated learning conduct and academic success in online community-college general education courses. University of San Francisco. Ragosta P., (2010), The effectiveness of intervention programs to help college students acquire self-regulated learning strategies: A meta-

analysis (Doctor of philosophy thesis), New York: The City University of New York.

Ramdass, D., & Zimmerman, B. J. (2011). Developing self-regulation skills: The important role of homework. *Journal of advanced academics, 22*(2), 194-218.

Santoso, T., & Yuanita, L. (2017, March). Metacognitive Analysis of Pre-Service Teachers of Chemistry in Posting Questions. In *Journal of Physics: Conference Series (Vol. 824*, No. 1, p. 012026). IOP Publishing.

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in science education, 36*(1), 111-139.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary educational psychology, 19*(4), 460-475.

Schraw, G., & Gutierrez, A. P. (2015). Metacognitive strategy instruction that highlights the role of monitoring and control processes. In Metacognition: Fundaments, applications, and trends (pp. 3-16). Springer, Cham.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational psychology review, 7*(4), 351-371.

Sebesta, A. J., & Bray Speth, E. (2017). How should I study for the exam? Self-regulated learning strategies and achievement in introductory biology. *CBE—Life Sciences Education, 16*(2), ar30.

Simpson, M. L., Hynd, C. R., Nist, S. L., & Burrell, K. I. (1997). College academic assistance programs and practices. *Educational Psychology Review, 9*(1), 39-87.

Singleton-Jackson, J. A., Jackson, D. L., & Reinhardt, J. (2010). Students as consumers of knowledge: Are they buying what we're selling?. *Innovative Higher Education, 35*(5), 343-358.

Stanton, J. D., Sebesta, A. J., & Dunlosky, J. (2021). Fostering metacognition to support student learning and performance. *CBE—Life Sciences Education, 20*(2), fe3.

toeger, H., & Ziegler, A. (2008). Evaluation of a classroom based training to improve self-regulation in time management tasks during homework activities with fourth graders. *Metacognition and Learning, 3*(3), 207-230.

Taboada, A., & Guthrie, J. T. (2006). Contributions of student questioning and prior knowledge to construction of knowledge from reading information text. *Journal of literacy research, 38*(1), 1-35.

Tise, J. C. (2018). The effects of a learning strategies intervention in a post-secondary stem class.

Tarricone, P. (2011). A taxonomy of metacognition. New York: Academic Press.

Trautwein, U., & Köller, O. (2003). The relationship between homework and achievement—still much of a mystery. *Educational psychology review, 15*(2), 115-145.

Tsaparlis, G. (2016). Concepts, theoretical constructs, models, theories and the varied and rich practice of "Relevant chemistry education". *Studies in Science Education, 52*(2).

Veenman, M. V. J. (2018). Final report talent education—metacognition. Leiden: SCOL.

Veenman, M. V. (2011). Alternative assessment of strategy use with self-report instruments: A discussion. *Metacognition and learning, 6*(2), 205-211.

Weinstein C. E., Acee T. W., Flippo R. F., & Bean T. W. (2018). Study and learning strategies, in Handbook of College Reading and Study Strategy Research, 227-240.

Weinstein, C. E., Acee, T. W., & Jung, J. (2011). Self-regulation and learning strategies. *New directions for teaching and learning*, 2011(126), 45-53.

Weinstein C. E., Jung J., & Acee T. W. (2010). Learning strategies. In *International encyclopedia of education*, pp. 323-329.

Weinstein C. E., & Mayer R. E. (1986). The teaching of learning strategies. In M, Wittrock (Ed.), Handbook of research on teaching (pp. 315-327). New York: Macillan,

Wolters, C. A., Shirley, L. Y., & Pintrich, P. R. (1996). The relation between goal orientation and students' motivational beliefs and self-regulated learning. *Learning and individual differences, 8*(3), 211-238.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational psychologist, 25*(1), 3-17.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In Handbook of self-regulation (pp. 13-39). Academic press.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of educational psychology, 81*(3), 329-339.

Zimmerman, B. J., Bonner, S., & Kovach, R. (1996). Developing self-regulated learners: Beyond achievement to self-efficacy. American Psychological Association.

Author Details

Funda Ekici, *Gazi University, Turkey,* **Email ID***: fundaekici@gazi.edu.tr*

Basri Atasoy, *Gazi University, Turkey,* **Email ID***: batasoy@gazi.edu.tr*