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Exploring the Sources of Turkish Pre-service Chemistry Teachers' Chemistry Self-efficacy Beliefs

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Abstract: This study aimed to examine the underlying sources in developing chemistry self-efficacy beliefs of Turkish pre-service chemistry teachers. For this purpose, the College Chemistry Self-efficacy Scale (CCSS) was administered to 20 pre-service chemistry teachers. Then, phenomenological approach was employed and semi-structured interviews were conducted with five pre-service teachers selected based on their scores on the CCSS to identify the underlying sources. The emerging meanings and self-reported sources of participants' chemistry self-efficacy beliefs were analysed according to Bandura's sources of self-efficacy. Results indicated that mastery experiences were the major source of self-efficacy beliefs, supporting the tenets of social cognitive theory. Physiological arousal and vicarious experience were also influential but they were not as frequently reported as mastery experiences.

In science education, perceived self-efficacy belief, which is the central element of social cognitive theory, has been interest of researchers over past decades (Andrew, 1998; Baldwin, Ebert-May, & Burns, 1999; Britner & Pajares, 2006; Dalgety, Coll, & Jones, 2003; Dalgety & Coll, 2006a, 2006b; Mulholland & Wallace, 2001). Perceived self-efficacy is defined as 'people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances' (Bandura, 1986, p. 391). People tend to engage in tasks they believe they have capability to do successfully and tend to avoid tasks they believe they are less competent in performing. Science self-efficacy has been found to predict academic achievement better than other variables such as gender and parental background (Andrew, 1998; Britner & Pajares, 2001; Kuppermintz, 2002; Hampton & Mason, 2003; Lau & Roeser, 2002; Pajares, Britner, & Valiante, 2000). Also, a significant relationship was observed between self-efficacy and course selection, career decision, interest, motivation, and self-regulation (Pintrich, 1999; Pintrich & De Groot, 1990; Schunk, 1989, 1991; Wigfield et al., 1997; Zeldin, Britner, & Pajares, 2008; Zimmerman, 2000). Considering these associations, the focus of self-efficacy studies has turned to the origins and supports of self-efficacy beliefs. Researchers suggest employing qualitative studies complementary to quantitative ones to provide in-depth description of efficacy beliefs (Pajares, 1996; Schunk, 1991). Accordingly, in the present study, the purpose was to examine the underlying factors in developing chemistry self-efficacy beliefs of Turkish pre-service chemistry teachers.

Social cognitive theory (Bandura, 1986) explains the interaction between self-efficacy beliefs and behaviour by a model of reciprocal determinism in which behaviour, cognitive, and environmental factors are highly interdependent. People's interpretation of their performance informs and changes their environment and their beliefs about themselves, which in turn inform and change their subsequent behaviour. Bandura (1997) contended that people's beliefs about their ability predict the subsequent behaviour better than their knowledge or prior attainments. In particular, students' choices of science-related activities, their efforts to perform them successfully, and their persistence and resilience in overcoming obstacles are more affected by their self-efficacy beliefs than by their prior knowledge. Students with high self-efficacy beliefs are likely to select more challenging tasks and show more effort and persistence to accomplish them. This explains the reason of the difference in the academic performance of students of similar ability (Pajares, 1997). In addition, self-efficacy is task and domain specific. For example, students' high self-efficacy in chemistry does not mean that they have high self-efficacy in history. Therefore, researchers should be careful in assessing and interpreting students' judgments about their abilities to perform required tasks within a specific domain (i.e., chemistry in this study).

Because task and domain specificity are characteristic of self-efficacy, researchers should examine the construct of self-efficacy within each domain of science: chemistry, physics, etc. Although, as mentioned before, there are numerous studies of students' science self-efficacy beliefs in the literature, the number of these studies is low in the area of chemistry. In line with the definition of self-efficacy, chemistry self-efficacy beliefs can be defined as students' beliefs about their ability to accomplish chemistry tasks. Several instruments have been developed to identify students' chemistry self-efficacy beliefs. One of them was the Chemistry Attitudes and Experience Questionnaire developed by Dalgety, Coll, and Jones (2003). Using this instrument, Dalgety and Coll (2006a) found a significant difference between first-year chemistry students intending to enrol and not intending to enrol in the second-year chemistry course in terms of their chemistry self-efficacy beliefs. Students who believed they achieved in chemistry tasks in the first year stated this as a reason for studying at second-year level. In addition, students did not have high self-efficacy in all areas of chemistry; they believed less in their ability in advanced skills, such as tutoring peers and designing experiments (Dalgety & Coll, 2006b). Uzuntiryaki and Capa Aydin (in press) developed an instrument called College Chemistry Self-efficacy Scale (CCSS) and reported three dimensions (self-efficacy for cognitive skills, self-efficacy for psychomotor skills, and self-efficacy for everyday applications) to determine college students' chemistry self-efficacy beliefs.

Bandura (1986, 1997) proposes four sources of self-efficacy beliefs: mastery experience, vicarious experience, social persuasion, and physiological and emotional states. Among these sources, mastery experience is the most influential. As students engage in tasks and activities and interpret their previous performance, they develop beliefs about their ability to do subsequent tasks and activities. Generally, successes increase efficacy beliefs whereas repeated failures decrease them. If one develops high self-efficacy beliefs as a result of repeated successes, occasional failures are unlikely to affect one's beliefs. Students with high self-efficacy beliefs are likely to attribute the causes of failure to situational factors, insufficient effort or poor strategies and think that better strategies will lead to success in future. On the other hand, successful experiences alone do not raise efficacy beliefs; instead, personal and environmental factors, which include cognitive processing of previous performance, perceived task difficulty, effort on task, and help received from other people, influence the formation of self-efficacy beliefs. Another source of self-efficacy beliefs is vicarious experience. If individuals are not sure about their capability and have less prior experience, their self-efficacy judgments tend to depend on vicarious experience. Observing other people perform successfully can enhance one's self-efficacy beliefs. Likewise, others' failure can lower one's self-efficacy. Vicarious experience is more effective when the observers see similarities between the model and themselves. People also develop self-efficacy beliefs as a result of social persuasion, which involves verbal and non-verbal judgments from other people. Social persuasion, within realistic limits, can lead to successful performance: individuals put extra effort into accomplishing tasks and their self-efficacy is enhanced. On the other hand, negative persuasions may weaken self-efficacy beliefs. Lastly, physiological and emotional states, such as anxiety, stress, and arousal, influence the formation of self-efficacy beliefs. Individuals' negative thoughts or fears about their ability to do tasks successfully can lower their self-efficacy beliefs.

Individuals use the combination of these sources in their self-efficacy judgments. The effect of each source depends on the domain and cognitive processing strategies of the individual (Britner & Pajares, 2006). Related literature indicates the relationship between the sources and self-efficacy, as well as among the four sources (Anderson & Betz, 2001; Cantrell, Young, & Moore, 2003; Klassen, 2004; Lent, Lopez, & Bieschke, 1991; Lopez & Lent, 1992; Usher & Pajares, 2006a; Usher & Pajares, 2006b; Zeldin & Pajares, 2000). In the majority of the studies, mastery experiences have been found to be the most influential source. However, except for mastery experiences, there are inconsistent results about the strength of predictors of self-efficacy. For instance, while some research found that vicarious experience made a major contribution to self-efficacy (Hampton, 1998; Klassen, 2004), others revealed no influence (Anderson & Betz, 2001; Lopez & Lent, 1992). Also, in terms of social persuasion and physiological states, there have been inconsistent findings (Anderson & Betz, 2001; Hampton, 1998; Klassen, 2004; Lopez & Lent, 1992).

It has been reported that sources of self-efficacy differ in terms of gender, ability level, and efficacy for the use of self-regulatory strategies. Females have been found to be affected more by vicarious experiences and social persuasion than males (Anderson & Betz, 2001; Zeldin & Pajares, 2000). Hampton (1998) explained that academic self-efficacy beliefs of learning disabled students were influenced only by mastery and vicarious experiences. Students with high self-regulatory efficacy had high self-beliefs in their academic capabilities (Zimmerman, Bandura, & Martinez-Pons, 1992). These students believed in their ability to use metacognitive strategies to accomplish a task, which may have shaped their self-efficacy beliefs (Pajares, 2002).

Besides considering students' chemistry self-efficacy beliefs and their sources, investigating teachers' chemistry self-efficacy beliefs and their antecedents is important for the quality of their teaching. Bandura (1986) claimed that self-efficacy beliefs develop early in learning. Therefore, teacher education is important in shaping pre-service teachers' chemistry efficacy beliefs. It can be proposed that, based on social cognitive theory, teachers who believe in their competence in chemistry (in other words, teachers with high chemistry self-efficacy) are more likely to engage in chemistry tasks, put more effort to overcome difficulties, and more willing to start their careers as chemistry teachers. Therefore, strong chemistry self-efficacy belief becomes a desirable teacher characteristic.

The aforementioned literature indicates the importance of self-efficacy beliefs in terms of both learning and teaching chemistry. The following questions provided the research framework for the present study:

- How can we, as researchers and teacher educators, better understand chemistry self-efficacy beliefs?
- What are the antecedents of chemistry self-efficacy?
- How do pre-service chemistry teachers develop chemistry self-efficacy beliefs?

It was expected that answering these questions would provide richer insights for science education, as well as for teacher education as a whole, in designing learning environments that enhanced self-efficacy.

Method

Participants

Five pre-service chemistry teachers (three females and two males) participated in the study. These teachers were selected from among 20 (12 females and eight males) attending teaching methods class at a faculty of education. The College Chemistry Self-efficacy Scale (CCSS) developed by Uzuntiryaki and Capa Aydin (in press) was administered to all students in the course in order to determine their self-efficacy beliefs. The items in this scale were developed considering basic tasks in chemistry and experiences of researchers and teachers. For the content validation, a group of 11 experts in chemistry, chemistry education, educational psychology, and educational measurement examined the scale to evaluate the quality of each item, to match each item to the corresponding dimension, and provide further suggestions. The final form of the CCSS was obtained as a result of exploratory factor analysis to determine the factor structure of the CCSS, confirmatory factor analysis to cross-validate the scale, and reliability analysis for internal consistency (Please refer to Uzuntiryaki and Capa Aydin for further validation information). The CCSS contained 21 items on a nine-point rating scale, ranging from 'very poorly' to 'very well.' It had three dimensions: self-efficacy for cognitive skills (12 items), self-efficacy for psychomotor skills (five items), and self-efficacy for everyday applications (four items). The self-efficacy for cognitive skills dimension was related to beliefs in an ability to understand intellectual operations in chemistry. The self-efficacy for psychomotor skills dimension included items on beliefs in an ability to use muscle skills. The self-efficacy for everyday applications dimension was about one's beliefs in an ability to use chemistry knowledge in real-life situations. Sample items for each dimension are given below:

- How well can you describe the structure of an atom? (self-efficacy for cognitive skills dimension).
- How well can you work with chemicals? (self-efficacy for psychomotor skills dimension).
- To what extent can you propose solutions to everyday problems by using chemistry? (self-efficacy for everyday applications dimension).

Internal consistency reliabilities (Cronbach alpha coefficients) were found to be 0.92 for self-efficacy for cognitive skills, 0.87 for self-efficacy for psychomotor skills, and 0.82 for self-efficacy for everyday applications, indicating satisfactory reliability.

The scale was scored by calculating the mean scores of the respondents' ratings ranging from 1 for 'very poorly' to 9 for 'very well' for each item within a dimension. Getting a high score on each dimension meant that teachers had high chemistry self-efficacy beliefs on the corresponding dimension. The teachers answered the items in the scale in a class hour in about 10-15 minutes. Then, based on their scores on each dimension on the CCSS, a total of five pre-service teachers were chosen for the study to represent a wide range of self-efficacy beliefs: 'Ali' and 'Oya'[1] had the highest self-efficacy scores in all three dimensions among the 20 pre-service teachers. 'Ece' had the lowest self-efficacy score in all three dimensions. The scores of 'Filiz' and 'Bora' were inconsistent. Filiz was efficacious in cognitive skills and everyday applications; however, she got one of the lowest scores in self-efficacy for psychomotor skills. Similarly, Bora had one of the highest scores in self-efficacy for cognitive skills and self-efficacy for psychomotor skills and the lowest score in self-efficacy for everyday applications.

[1] All names are pseudonyms.

Profiles of the Participants

The participants in the study attended a five-year integrated chemistry education program in the Faculty of Education, in which students are granted a non-thesis Masters degree upon graduation in addition to a bachelors degree. In this program, students initially take chemistry classes from the Department of Chemistry and then they complete the courses related to teaching profession in the Department of Educational Sciences and Department of Secondary Science and Mathematics Education. Graduates are employed as chemistry teachers in either public or private schools.

All the participants were 23 years old and in their last semester of the program at the time of this study. They completed the required chemistry classes in the chemistry education program of the university and took few elective chemistry classes. Almost all stated that chemistry classes were based on lecturing, without any interaction between teacher and students, during their high school and university education. In addition, in the high schools, they did not have much opportunity for conducting experiments in laboratories.

Oya

Oya's grades on chemistry were above the class average. She had graduated from the Chemistry Vocational High School, which trains students for a career in chemistry. These vocational high schools follow a three-year program and have a different curriculum from other high schools in that they have more courses from different branches in chemistry, such as organic chemistry or analytical chemistry. Students in these schools have the opportunity to attend chemistry laboratories more often than the students attending other high schools. Moreover, they must complete a field practice. After graduation, students can work either as chemical technicians or continue their education in the area of chemistry. Oya had had her field practice in a chemistry institute. She scored 7.58 (self-efficacy for cognitive skills), 8.60 (self-efficacy for psychomotor skills), and 8.50 (self-efficacy for everyday applications) on the CCSS out of 9.00.

Ali

Ali also had higher grades than class average. He had graduated from a public high school that followed a three-year program and did not have a field practice, but in the university he had such a practice. Although his program did not have such a requirement, he had taken this practice voluntarily. Also he was studying in a chemistry project with one of the professors in the department of chemistry. He scored 7.83 (self-efficacy for cognitive skills), 9.00 (self-efficacy for psychomotor skills) and 8.50 (self-efficacy for everyday applications) on the CCSS.

Filiz

Filiz's grades were around average. She had graduated from a public high school. She had not participated in any chemistry project in the high school or university. Filiz scored 6.92 (self-efficacy for cognitive skills), 4.80 (self-efficacy for psychomotor skills), and 8.25 (self-efficacy for everyday applications) on the CCSS.

Bora

Bora's grades were around average. In the university, he was working with a professor in organic chemistry. His scores on the CCSS were 7.83 (self-efficacy for cognitive skills), 9.00 (self-efficacy for psychomotor skills), and 4.50 (self-efficacy for everyday applications).

Ece

Ece's grades were around average. She had graduated from the same vocational high school as Oya. Therefore both had similar experiences in the high school, with more class hours devoted to chemistry. Ece did not work in any chemistry project in high school or university. On the CCSS, Ece's score for self-efficacy for cognitive skills was 5.58, for self-efficacy for psychomotor skills 6.00 and for self-efficacy for everyday applications 4.75.

Data Collection Method and Analysis

In order to elicit the underlying sources in developing the pre-service teachers' chemistry self-efficacy beliefs, the methodological approach of phenomenology was employed. In phenomenology, researchers try to explore how individuals make sense of and interpret the meaning of experience. Therefore, how people perceive, describe, and judge some phenomenon and talk about it with others is the focus of this type of qualitative inquiry. For this purpose, in-depth interviews with individuals who have had experience with the phenomenon are mainly used to collect data (Patton, 2002). In this study, semi-structured interviews were conducted with the five pre-service teachers selected on the basis of their scores on the CCSS. The interview questions were prepared after consideration of the related literature (Britner & Pajares, 2006; Dalgety, Coll, & Jones, 2003; Zeldin, Britner, & Pajares, 2008). They were based mainly on Bandura's four assertions about the sources of self-efficacy beliefs. However, leading questions that referred directly to the sources of self-efficacy were avoided. Instead, open-ended questions that related to the participants' experiences and beliefs were used to explore the sources. Additional questions were asked during the interviews when the participants did not articulate the sources of their self-efficacy beliefs clearly. Interviews were conducted in one-to-one settings and lasted for approximately 45 minutes. All interviews were audio-recorded with the interviewees' consent and transcribed verbatim for the analysis. The transcripts were analysed for thematic content (Bogdan & Biklen, 1998; Patton, 2002) by considering the dimensions of the CCSS to find common themes in each and reduce the data into categories and sub-categories.

In an effort to improve the quality and credibility of findings and to reduce the bias that might come from a single researcher collecting and analysing the data, an independent researcher analysed the transcripts for recurring themes and compared the findings with those of the primary researcher (Patton, 2002). An inter-rater reliability analysis (Kappa statistic) was conducted to determine consistency among the raters. The Kappa coefficient was found to be .87, which showed good level of agreement (Miles & Huberman, 1994).

Results

Results are presented in three categories as sources of self-efficacy for cognitive skills, sources of self-efficacy for psychomotor skills, and sources of self-efficacy for everyday applications, parallel to the dimensions of the CCSS. Under each category, sub-categories are explained, based on the sources of self-efficacy proposed by Bandura (1986, 1997). Table 1 presents the categories, sub-categories, and number of participants who expressed the sources of their self-efficacy beliefs in each category, based upon consensus of the raters.

Categories/Sub-categories	Number of responses
Sources for self-efficacy beliefs for cognitive skills	
Mastery experiences	
Studying and reviewing concepts	3
Studying strategy	1
Chemistry knowledge	1
Ability	1
Physiological arousal	1
Sources for self-efficacy beliefs for psychomotor skills	
Mastery experiences	4
Vicarious experiences	1
Physiological arousal	1
Sources for self-efficacy beliefs for everyday applications	
Mastery experiences	
Chemistry knowledge	5
Studying strategy	2
Interest	1

Table 1: The number of participants' responses for each sub-category of the sources of self-efficacy beliefs

Sources of Self-efficacy for Cognitive Skills

When the participants were asked how well they believed they could explain fundamental principles and theories in chemistry, all except Ece stated that they could explain most of the chemistry topics well. In addition, they mentioned they could solve most of the chemistry problems successfully. The sub-categories explaining the underlying sources of the participants' self-efficacy for cognitive skills are described below.

Mastery Experiences

The participants mostly considered studying and reviewing the concepts, studying strategy (how to study chemistry), and previous knowledge as important in gaining an understanding of chemistry topics.

Three emphasised that it was important to study hard to understand **chemistry concepts** and to gain confidence in explaining chemical principles and theories. For example:

Filiz (F): I can explain chemistry topics well except electrochemistry.
Researcher (R): Why do you think like that?
F: Because I am forgetting details in electrochemistry. Usually, I study again and again… I became aware that for me, to understand that topic depends on solving a lot of problems about it. I will overcome this by solving problems.
R: Why do you believe that you can explain other topics?

F: Well, when I think of my chemistry classes, I was successful and I know that I can do it again. That makes easy for me to understand (chemistry). In other words, it is related to self-confidence.
R: Why do you think you become successful?
F: By studying and attending classes

In addition, two of them stated that since they were working on a project with a professor, they had the opportunity to review the concepts during the project:
...I can explain the concepts in organic chemistry because I am working on this area. However, I may not explain some concepts in other areas like physical chemistry because I am not reviewing the concepts in physical chemistry; I have had no practice since I got that class. However, I am reviewing organic chemistry because I am working on a project. Actually, I cannot say I forgot physical chemistry [concepts], maybe they are somewhere in my mind but because I am not using what I learnt, I may not explain the concepts. I can remember if I review...I can solve every problem in high school chemistry. For university chemistry, it depends on the topic. I need to review the concepts.

All of these pre-service teachers' beliefs were similar in that they expressed they needed to study and review chemistry in order to explain concepts. In particular, working on a project enabled them to use their knowledge. The more they studied chemistry and became successful, the higher the self-efficacy beliefs they had. They stressed their past successful experiences with chemistry and these experiences enabled them to conclude that they had the ability to succeed. All of these experiences might increase their self-efficacy. Therefore, the major source of these participants' high self-efficacy beliefs seemed to be mastery experiences, consistent with Bandura's assertion.

Only Ece emphasised **studying strategies** as a source of chemistry self-efficacy beliefs:
Ece (E): I do not think that I can explain chemistry concepts well. Actually, I know something but I could not express it...I mean I may answer the problem correctly but I may not explain the concepts behind the problem. I couldn't internalise concepts. Therefore, I am not confident in chemistry. Maybe, I can explain high school topics but in the university, topics are more detailed and I cannot explain them.
R: Why do you believe so?
E: My memory is bad. I learn something, memorise, and forget.

This excerpt indicated that her studying strategy might be a reason for her lower self-efficacy than the others. It seemed that since she did not comprehend the relationships among chemistry concepts, she believed that she couldn't explain them. She said that when she thought that she could not achieve success in a chemistry class, she would withdraw from that class and take it next semester. This indicated her belief in her weakness in performing a task. According to the literature, people with high self-efficacy beliefs do not give up easily when faced with obstacles (Bandura, 1986, 1997). Therefore, Ece's behaviours can be taken as evidence of her relatively low self-efficacy. In addition, because her comments were based on her past experiences, the main source of her low self-efficacy was mastery experiences.

Filiz was the only participant who believed that she could solve chemistry problems successfully because she was competent in **chemistry knowledge**:
I can solve problems correctly. I believe we had good training in chemistry here. Actually my grades were always average, around 2.5 out of 4.00. To me, this means that I learned at least half of the topics taught.

Filiz has high self-efficacy in cognitive skills. To her, the main reason for this was her education on chemistry in the university and past successful performance on the courses. Therefore, she emphasised mastery experiences as a source of self-efficacy.

Ability

Oya believed that she had the ability to understand chemistry. She described her ability to explain chemical principles and theories in the following:
Oya (O): I think I have ability in chemistry because I realised that I can connect concepts to each other very well. I can understand the topics without studying too much; I can understand what the instructors say. Also, I am very skillful in laboratories. When compared with other areas like physics or mathematics, I think that I easily understand and interpret on chemistry topics. I have confidence in chemistry. Therefore, I think that I have ability in chemistry.
R: Why are you confident?
O: Because people have confidence on the issues they have knowledge. For example, when I attend classes, I can realise that I am different from the other students in the class. While they are thinking on the issues, I can easily figure them out…I never worried about grades, I just studied for learning. Usually, I did not have problems, I did not get bored.
R: How do you think you gained this ability?
O: I didn't know I had ability during secondary school. During high school, I understood I had ability; in the university I became sure about it. In the second year, I realised that I like chemistry and I started studying hard and I realised my ability.

Oya also believed that she could solve chemistry problems successfully because she was successful in chemistry. She stated that it might take time, she might have difficulty, but she would make a search on the problem and solve it.

She indicated high self-efficacy in cognitive skills. She was the only participant who attributed success in chemistry to ability in chemistry tasks, which might enhance her self-efficacy. In solving chemistry problems, she stressed that even if she could not solve them at first, but after studying she believed that she could do so. These ideas were also consistent with the literature stating that highly self-efficacious people show more resilience in overcoming difficulties than people with low self-efficacy beliefs (Bandura 1986, 1997).

Physiological Arousal

Only Ece talked about her health problem as a reason for her difficulty in understanding the instructor in class:

> *I cannot explain the concepts in chemistry well. I don't listen to the instructor in class. I study by myself reading the textbook. Actually, I have a problem in my ear. One of my ears does not hear due to middle ear inflammation. My other ear also hears less. Therefore, I rarely hear; I hear but I cannot understand what people say, I hear just some sounds. This is a big problem for me and very stressful. I just began to use hearing aid. Therefore, I could not listen to the instructor in class.*

When the researcher asked about solving a chemistry problem, she answered that she could solve computational questions, but gas concepts were the most difficult for her and therefore she stated that she couldn't solve any problems on gases.

It seemed that Ece was not as self-efficacious as the other four pre-service teachers during the interview. One of the major reasons of her low self-efficacy might be her health problem, which then led her to have less successful experience in chemistry. Because of the problem in her ears, she couldn't be involved fully in classes, couldn't follow the instructions, and couldn't understand the topics. This might result in stress and anxiety, which might lower her self-efficacy beliefs. Therefore, as Bandura (1986) stated, her physiological arousal affected her performance. Actually, Bandura explained this situation by claiming that people who perceived their arousal due to their own personal inadequacies tended to have lower self-efficacy beliefs than those who viewed their arousal as common even among competent people. Ece's attribution of her failure in understanding classes to her personal inadequacies might have lowered her self-efficacy.

Sources of Self-efficacy for Psychomotor Skills

Participants were asked if they ever thought that they could not conduct an experiment and the reasons for their answers. Four believed that they could conduct any experiment and explained their self-efficacy beliefs by previous successful laboratory practices. This could be categorised under 'mastery experiences.' One stated that he benefited from others' experiences when faced a difficulty, which emphasised 'vicarious experiences.' One believed she could not conduct laboratory experiments and pointed to her health problem as a source of self-efficacy.

Mastery Experiences

The pre-service teachers' past practices in laboratories were grouped under this sub-category. Four said that they definitely did not think that they could not undertake an experiment because they had been to laboratories many times and performed the experiments successfully, indicating the role of mastery experiences in the formation of self-efficacy beliefs. Ali stated that he could undertake any experiment in chemistry because he had been working in an organic chemistry laboratory for nearly two years. He said:

> *I can set the apparatus, understand the steps and the reasons for performing those steps in the procedure; why do we add that chemical, why don't we use other chemicals, etc. I can understand all the parts.*

Bora answered the interview question related to performing a chemistry experiment as:

Bora (B): I can make every experiment in chemistry provided that the procedure is given. Also, I try to understand the logic of the experiment.
R: Why do you think you can make it?
B: So far, I saw that I can do well in laboratories and I can reach to conclusion. I have muscle skills.

Oya also believed that she could undertake experiments and she added that even if she could not, she would know in which part she had a mistake; she could interpret the data and understand the concepts. She said that if she thought she could not undertake an experiment – she stressed it had never happened – she would get help from others. This response was not put into category related to verbal persuasion (Bandura, 1997) by the researcher because Oya didn't experience such an event; she just talked about a hypothetical situation.

Lastly, Ece stated that she never believed she could not undertake an experiment because she had been to laboratories since high school:

I have been studying in laboratories for nearly seven years, thus, I don't think that I cannot make an experiment.

Ece thought that it was fun to study in laboratories and stressed that she liked studying in them.

The sources of these participants' self-efficacy beliefs in psychomotor skills could be explained by mastery experiences. As they were working in laboratories and performing experiments successfully, they became self-efficacious. Extra work on laboratories increased their efficacy.

Vicarious Experience

In terms of self-efficacy for psychomotor skills, Bora stated that he had had a negative experience during one of the laboratory sessions:

B: A friend of mine, working on the bench behind me, caused fire with acetone. Nothing happened, it was a small accident…Moreover, I did something…I poured sodium hydroxide to my hand and then I tried to clean it with water, I burned a bit. I should not have done this…It was very simple but I did.

R: Do these events influence your beliefs in your ability in performing chemistry experiments?

B: No. I just began to be more careful. Actually, it is chemistry, it happens…. I know when I started studying chemistry, some small accidents like these may occur. The events I mentioned were small therefore I didn't care about them very much. I mean, I thought of instructors and assistants working in laboratories and I saw that each had such experiences. I thought that if they come to this point in their career, I can do, too.

Bora observed others like him working in the laboratory when he had accidents and concluded that he could proceed with the experiments. This may be evidence of vicarious experience as one of the sources of self-efficacy suggested by Bandura.

Physiological Arousal

Only Filiz said that she often thought she couldn't perform a chemistry experiment:

F: Well…. First of all, my perspective to experiments is not good.

R: What do you mean?

F: I cannot make experiments. I even cannot touch chemicals. It makes me stressful. I hate them (laughing)

R: Why?

F: I am afraid of being injured. Chemicals may be carcinogens, then I do not want to touch. So far, in laboratories my partners did most of the work. I do not like and I am breaking everything. Especially, experiments in organic chemistry are difficult to make for me. I can perform simple experiments but when we need to use a lot of chemicals…In addition, our assistants in laboratories make me frightened because they say 'be careful, this is harmful, do not inhale', when they said this, I could not do anything. Okay, they are saying this for precaution but then I don't want to make the experiment when they say[things] like that.

Filiz was not so self-efficacious in her psychomotor skills because she was afraid of working with chemicals. She became anxious and stressful as she thought that she might get injured. During the interview, Filiz explained that she had a surgery in her intestine and her doctor warned her about the risk of there being cancer. Therefore, she didn't want to work with chemicals. Bandura explains that negative physiological states interfere with performance and may prevent success, leading to lower self-efficacy. Her health problem might decrease Filiz's self-efficacy in psychomotor skills.

Sources of Self-efficacy for Everyday Applications

During the interviews it was observed that, the participants were not as highly self-efficacious for everyday applications as for cognitive and psychomotor skills. The sub-categories are explained below.

Mastery Experiences

The responses reflected mastery experiences as a source because they talked about their past successful experiences in chemistry either in school or at home.

All participants pointed to their **chemistry knowledge** in order to express their beliefs in explaining daily life events. During the interview, they recalled their experiences in chemistry classes. While Ece pointed to her lack of knowledge for not explaining daily life events, the rest of the participants stressed their competence in chemistry as a source for chemistry self-efficacy. Oya emphasised that she took many elective classes in which daily life events were discussed and she passed these classes with good grades:

R: How much do you think you can propose solutions for daily life problems related to chemistry?

O: Sometimes, when my mom cooks, I make some suggestions to cook faster. I can explain nuclear energy or global warming. Yes, I can propose solutions. I am taking a class on environmental education and we are discussing these issues. When I had polymer class, I understood its uses and misuses. I became more sensitive. I can explain the advantages and disadvantages of nuclear centrals and the points about which people should be careful when constructing nuclear central.

Ali believed in his ability in explaining most of the daily life events such as solubility of gases but he was not sure about proposing solutions for daily life problems like air pollution. When the reason was asked, he claimed:

> *I think I do not have enough knowledge. If I learn something on this issue, read books, and make a search on it, then I can explain. But because at the moment I have no knowledge, I cannot explain.*

Ali took elective classes in chemistry like Oya but these classes were mostly theoretical or based on laboratories rather than on discussion on daily life events. Having less experience might be a reason for not having a high self-efficacy belief.

Ece believed that advanced knowledge is needed to propose solutions to everyday problems and that she is not competent enough in chemistry to do this. These explanations were in line with mastery experiences, because participants interpreted their successful or unsuccessful past experiences from chemistry classes.

Oya and Ece addressed their **studying strategy** to explain sources of their self-efficacy beliefs in different ways. Oya stated that she could explain chemistry behind some daily life events:

O: …For example, I can explain gases, diffusion of cologne, the effect of temperature, etc.

R: Why do you think that you can explain them?

O: Because while I am studying, I ask the reasons and connect concepts to each other. I do not memorise, I try to comprehend the reasons. We see theoretical knowledge in our chemistry classes. The instructors explain topics without discussing the reasons, you have to develop them yourself. Therefore, in my opinion, everyone may have difficulty in explaining daily life events. It requires a different way of thinking.

It seemed that Oya had high self-efficacy in explaining daily life events and she tried to connect her chemistry knowledge to daily life events as a studying strategy. Therefore, these experiences might lead to an increase in her self-efficacy.

Ece, on the other hand, said that she might not explain every daily life events by using her chemistry knowledge because she could not construct the relationship between what she learned in the classes and daily life. She was aware that she just memorised some concepts:

I am using memorisation technique to learn something. Therefore, I forget most of the topics easily. I have difficulty in transferring what we learn in chemistry classes - physical chemistry, for example - to everyday life.

Ece did not have successful experience in dealing with daily life issues because of her ineffective studying strategy, leading to her having low self-efficacy beliefs. These statements reflected mastery experiences as a source of self-efficacy. According to Bandura, people's interpretations of their experiences affect their self-efficacy. Therefore, these expressions can be categorised under mastery experiences.

Only Filiz linked her self-efficacy beliefs in explaining daily life events to her **interest** in the topic. She stated that she might not explain everything, although she liked dealing with current issues. Her interest depended on the topic and she claimed she could explain daily life events related to medicine:

I can propose solutions to the problems in medicine that involve chemistry, but, for air pollution, for example…I cannot propose solutions.

Filiz stated a possible reason for this:

I like to search on medical topics. I like topics involving humans. But I may not propose solutions for air pollution because I am not affected directly.

Her explanations for this category might provide evidence for the source of mastery experience. Because of her illness, she might undertake searches on medicine and she could combine her chemistry knowledge with this medical information. Therefore, her experience on this issue might lead her to have a high self-efficacy belief. However, she was not so interested in air pollution; thus she did not investigate it and she had less experience. Consequently, she had a low self-efficacy belief in proposing solutions for air pollution.

Discussion and Conclusion

This study aimed to explore the underlying factors in developing chemistry self-efficacy beliefs of Turkish pre-service chemistry teachers through interviews with five pre-service chemistry teachers selected on the basis of their score on the CCSS. Findings were consistent with the assertions of social cognitive theory. Mastery experiences were the most influential sources for all three categories. Another three sources were also found to be effective, but less so than mastery experiences. Therefore, this study supports the results of Britner and Pajares (2006), Usher and Pajares, (2006a), and Zeldin, Britner, and Pajares (2008).

Most of the pre-service teachers identified studying as a source of their self-efficacy beliefs in chemistry. They stated that if they studied hard enough, they could understand the chemistry topics. Also, they emphasised the importance of reviewing in order to be successful and thus to have high self-efficacy. All of these comments are in keeping with Bandura's claim related to the mastery experiences, which says that as students gain experience with the task, they develop self-efficacy beliefs. Bandura also suggested that mastery experiences are the most influential source of self-efficacy. The pre-service teachers in this study recalled their previous experiences often. They referred to their successes during high school and university. The courses they had at the university in particular were essential in developing their self-beliefs. Getting good grades from these courses might increase their efficacy. Moreover, their beliefs can be used to explain that self-efficacy is domain specific because the participants stressed that their self-efficacy depended on the topic; for instance, they stated that they could explain organic chemistry well but for other areas they needed to review. Also, they believed in their ability to undertake experiments: almost all stated that they could perform any experiment because for many years they had been studying laboratory tasks. In addition, the courses that included everyday topics such as global warming and air pollution affected the formation of efficacy beliefs.

The pre-service teachers reported not only studying and reviewing but also the strategies they used while studying chemistry as a source of self-efficacy for both cognitive skills and for everyday applications. The pre-service teachers attributed importance to learning how to study to be successful and therefore to gain confidence in their ability to do chemistry tasks. While constructing relationships among concepts increased self-efficacy beliefs, memorising concepts lowered these beliefs. This situation can also be explained by Bandura's mastery experiences assertion because Oya, who employed meaningful learning strategies as she was studying chemistry, became successful and these positive experiences raised her efficacy. Pintrich and De Groot (1990) concluded that self-efficacy promotes cognitive engagement and the use of cognitive strategies, which enhances one's performance. Therefore, a bidirectional relationship can be considered to exist between studying strategy and self-efficacy, as also explained by the model of reciprocal determinism (Bandura, 1986, 1997).

Another source stated by the pre-service teachers was interest. Filiz referred to her interest to explain her self-efficacy beliefs for everyday applications. Her interest might lead her to deal with everyday topics more, reading a lot about the issues, and then proposing solutions. These experiences might increase her self-efficacy and can be linked to Bandura's assertions. On the other hand, there is debate about the role of self-efficacy beliefs in motivational constructs such as interest and value. Some researchers (Renninger, Hidi, & Krapp, 1992) argued that students first like some tasks and then engage in activity because of their personal interest; during the activity, they develop their knowledge and skills, leading to an increase in their self-efficacy beliefs. Others (Wigfield, 1994; Wigfield et al., 1997) suggested that students first develop competence and efficacy in an area and then their interest becomes stronger. Although there is no consensus on the causal ordering of the link between self-efficacy and motivational constructs, it is important that there be a reciprocal relationship between interest and self-efficacy (Linnenbrink & Pintrich, 2003).

Ability was also stated as a source of self-efficacy. In this study, Oya believed that she had ability in chemistry tasks and thus had high self-efficacy. Pintrich and Schunk (2001) stated that if someone attributes the success to internal factors such as ability, then self-efficacy is improved, which might be the reason for Oya's high self-efficacy.

This study showed that vicarious experiences were found to be effective after mastery experiences in the formation of self-efficacy for laboratory tasks. Pre-service teachers developed their self-efficacy beliefs by observing other, similar people. In particular, when they had a negative experience, they benefited from others' experiences to maintain their efficacy. Physiological states were also found to be influential. In the present study, two pre-service teachers had health issues (hearing, surgery). These caused the participants anxiety and stress during chemistry tasks and lowered their self-efficacy beliefs.

Implications for Teaching

Considering the role of self-efficacy beliefs in achievement, course enrolment, and career decision making, it is worth examining ways of increasing students' self-efficacy at all levels of education. Therefore, special attention should be given to the sources that shape self-efficacy beliefs. Because of the significant effect of mastery experiences on self-efficacy, students should be encouraged to have positive experiences with the chemistry tasks and they should be given opportunities to deal with daily life issues so that they develop strong self-efficacy beliefs. Inquiry-based activities may be especially effective. Britner and Pajares

(2006) suggested that science teachers should help students do these activities through scaffolding, which in turn will facilitate development of self-efficacy beliefs. At the same time, teachers should direct their students to interpret their mastery experiences because it is not simply mastery experiences that form self-efficacy beliefs but the interpretation of these experiences by individuals that has an impact on self-efficacy (Bandura, 1997; Pajares, 1996). Teachers should also give enough attention to the students with physiological problems that would provoke anxiety and decrease their self-efficacy. They can guide students to use relaxation and cognitive restructuring techniques to cope with stress and anxiety they experience in science-related tasks. In addition, teachers may increase students' self-efficacy beliefs through modelling. Successful students or scientists can be examples for students to accomplish tasks and develop efficacy beliefs. Similarly, teacher education programs should include a variety of learning experiences that would provide opportunities for pre-service teachers to experience success. For example, pre-service teachers can have curricular or extra-curricular chemistry activities in high schools or universities in which they use their knowledge. All of these opportunities will provide successful experiences and therefore, self-efficacy will be enhanced.

For further investigations, longitudinal studies can be conducted to monitor the development of chemistry self-efficacy beliefs through years. This research can be repeated with students from different educational levels and chemistry self-efficacy beliefs can be compared. In addition, experimental studies can be employed to examine the effect of different approaches on development of self-efficacy. Investigations on the antecedents of self-efficacy across grade levels and various learning environments can enable researchers to obtain deeper understanding of self-efficacy. Because there are limited studies on chemistry self-efficacy beliefs, it is hoped that the present study will help researchers to go one step further in investigating the formation of these beliefs.

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