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MAIN PAGE
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FOR AUTHORS
PRINCIPLES
ABOUT
ABSTRACTING - INDEXING
SITE MAP

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The Effect of a Guided Inquiry Method on Pre-service Teachers' Science Teaching Self-Efficacy Beliefs

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ABSTRACT

The aim of this study was to examine the effectiveness of a guided inquiry method for science teaching on elementary pre-service teachers' self-efficacy beliefs. In the study a pretest/posttest one group research design was used. The study sample that consisted of 101 second year pre-service elementary teachers who are registered to a science laboratory course in the 2008 Spring semester. At the beginning of the study, the *Elementary Science Teaching Efficacy Belief Instrument (STEBI)* was completed by the participants. A 14-week science laboratory course was taken by the learners that was designed to use a guided inquiry teaching method with heavy reliance on the use of science process skills. At the end of the course the STEBI was again completed by the pre-service teachers. The data were analyzed by using paired sample t-test with the SPSS 16.00 program at the 0.01 significance level. Focus group interviews were also conducted with 10 groups of participants after they completed the course. Qualitative and quantitative findings indicated that levels of participants' efficacy expectations and outcome expectations on posttest scores were higher than the pretest scores. The paper also presents the effectiveness of a guided inquiry method to increase the sense of self-efficacy beliefs of pre-service teachers in science teaching.

Keywords: Self-Efficacy Beliefs; Guided Inquiry Teaching; Science Teaching; Pre-service Teachers.

INTRODUCTION

The term "self-efficacy" was proposed by Bandura (1986) and defined as the "judgment of one's capacity to accomplish a certain level of performance" (p.391). It seems to imply a degree of preparedness by virtue of training, experience, or talent (Housego, 1992). According to Bandura's (1981) theory of social learning, an individual's self-efficacy refers to that person's judgments about how well one can organize and perform an action that has unpredictable and stressful components.

Bandura (1977) described two critical components of self-efficacy. The first component is "efficacy expectation," which represents the belief in one's ability to successfully perform the behavior. The second component of self-efficacy is "response-outcome expectancy," which is the belief that the performance of the behavior will have a desirable outcome. Bandura (1997) focused a number of studies of teacher behavior and found that teachers who have a high sense of self-efficacy have a strong desire to teach, make efforts to motivate students and provide students with guidance. At the same time, teachers with low self-efficacy spend less time on instruction, make little effort to motivate students, and have an authoritarian approach. Teachers with higher self-efficacy

in a particular subject perform better and are more likely to be interested in a career in that field, persevere in difficult situations, and see complexity as a challenge rather than a threat (Ketelhut, 2007) and have a high degree of confidence in their teaching abilities (Camgöz & Tektaş, 2008). Likewise, Bıkmaz (2004) points out that the level of self-efficacy of teachers directly affects their practices in classrooms with students. The author also argues that teachers with higher self-efficacy are filled with passion of teaching compared to teachers with lower self-efficacy. Pajares (1992) also discussed the behavioral differences between teachers who have high and low senses of self-efficacy beliefs and choose specific strategies to enhance learning. Teachers with lower self-efficacy are less likely to do the above and more likely to equate failure to bad luck and poor ability (Ketelhut, 2007) and presume that a problem is more complex than it is (Pajares, 1992).

Similarly, most of these studies agree that negative feelings overshadow achievement in science as an influence on science teaching self-efficacy (Tosun, 2000). Many teachers lack a sense of school science self-efficacy (Bencze & Upton, 2006; Palmer, 2006), which is an important predictor of performance in classroom teaching (Yılmaz-Tüzün & Topçu, 2008). Unfortunately, teachers may not be equally effective (Enochs & Riggs, 1990) and avoid teaching science (Bencze & Upton, 2006) largely because of their inexperience and lack of confidence with the subject.

This is one of the important issues in teaching science. Elementary school teachers are responsible for teaching the entire science curriculum, including various biology, chemistry, physics, and earth science subjects at different grade levels. Over the past four decades, numerous studies have been conducted to examine levels of science teaching self-efficacy beliefs among pre-service teachers' (Akbaş & Çelikkaleli, 2006; Bencze & Upton, 2006; Bursal, 2008; Moseley, Reinke, & Bookout, 2002; Palmer, 2006; Plourde, 2002; Schoon & Boone, 1998; Tosun, 2000) and pre-school teacher candidates' (Vural & Hamurcu, 2008) .

In this regard, a considerable amount of research has also focused on how to improve self-efficacy among pre-service teachers. Several factors and strategies have been identified that have the potential to increase self-efficacy of pre-service teachers. These studies looked into the effects of many dimensions of science teaching and teacher preparation, including the use of an inquiry approach (Jarrett, 1999; Ketelhut, 2007), projects with individual children (Flick, 1990); hands-on, minds-on teaching experiences (Pedersen & McCurdy, 1992; Vural & Hamurcu, 2008; Weinburgh, 2007), student teaching experiences (Palmer, 2006) a responsive classroom approach (Rimm-Kaufman & Sawyer, 2004), site-based approach (Wingfield & Ramsey, 1999), drama-based action research (Bencze & Upton, 2006); and science knowledge level (Schoon & Boone, 1998). Generally, findings of all the studies listed above showed that pre-service teachers who reported using more of the intervention factors reported greater self-efficacy beliefs. This means, therefore, that science teaching self-efficacy is amenable to change depending on the experiences of the teacher.

A number of other studies found that well-designed science methods courses that are generally taught at the third year in a program can be successful at raising levels of science teaching self-efficacy (Flick, 1990; Morrell & Carroll, 2003; Palmer, 2006; Utley, Moseley & Bryant, 2005; Watters & Ginns, 1995). In his longitudinal study, Palmer (2006) worked with pre-service teachers and looked at the effectiveness of a science methods course on their self-efficacy beliefs and their performance in their student teaching with students. The researcher found that the course had increased pre-service teachers' beliefs about their ability to perform teaching behaviors even after only 11 months of instruction. Palmer (2006) also interviewed his students and reported that there

were strong positive changes in self-efficacy as a result of the course. Similarly, the research conducted by Utley et al. (2005) indicated that as science teacher education in a methods course progressed, science teaching efficacy significantly increased.

In addition to the methods and treatments that have positive impacts on pre-service teachers' science teaching self-efficacy beliefs, the adventures beyond the classroom (ABC) program was used as another strategy by Moseley et al. (2002) in an attempt to enhance pre-service teachers' attitudes toward self-efficacy and outcome expectancy. However, they found that the ABC program was not effective and the participants' self-efficacy beliefs were higher before the program than after. Also, their findings indicated that for the control group the level of science self-efficacy remained unchanged as a result of the methods class, but dropped significantly approximately 7 weeks after teaching. Similarly, Plourde (2002) stated that student teaching did not affect second year pre-service elementary teachers' science teaching self efficacy and outcome expectancy beliefs. Also, Bursal (2008) stated that the pre-service elementary teachers in their third year of pre-service programs did not increase their personal teaching efficacy beliefs scores (PSTE) after completing a science methods course, but slightly decreased instead. This suggests that not all approaches to teaching science methods will increase students' science teaching self efficacy.

Plourde (2002) and Watters and Ginns (1995) that certain attributes of teachers' professional identities, such as behaviors, values, and beliefs, may be formed on their early experience as a student teacher. These attributes may be affected by science teaching self-efficacy. Since many teachers formulate their self-efficacy beliefs much earlier than they actually start teaching these subjects, it is very useful to determine and adjust their levels of self-efficacy in the early years of their elementary teacher training programs. Therefore, in the current study, a guided inquiry, which has a potential to be one of the factors listed above that increase self-efficacy of pre-service teachers, was applied to second year students in the science laboratory course.

A continuum of different methods of science teaching is explained in many resources in the science education literature (Martin, 1997; Furtak, 2006). At one side of the continuum, there is a traditional, direct instruction didactic technique where the teacher tells factual information to learners (Furtak, 2006). At the other side of the continuum there is open-ended scientific inquiry where learners design and conduct their investigations by themselves. In the more open ended approaches to inquiry-based instruction, there might be problems such as whether the students are clear about the learning intention, whether they have high enough motivation, and whether they have suitable cognitive and experiential skills. Guided scientific inquiry teaching takes place somewhere between the two extremes, where students are guided through a process of scientific investigation in a learning-by-doing model. In guided inquiry, the teacher sets the direction and suggests open-ended activities, which the children pursue to find out what they can discover and inquire into what they don't understand (Martin, 1997). This method is a student-centered and activity-based teaching strategy where a teacher uses a variety of instructional materials to help students discover possible and testable solutions to their defined scientific investigations (Nwagbo, 2006).

Many educational studies have explored the effectiveness of scientific inquiry teaching on learner performance (Furtak, 2006). Schwarz and Gwekwerere (2006) stated that inquiry practices are very important in terms of forming scientific knowledge. The authors also found that pre-service teachers who experienced guided inquiry and modeling as part of the instructional framework improved their prior ideas of science teaching and felt that the course had increased their knowledge on how to teach science. Similarly, Nugent et al. (2008) found that field-based inquiry-focused models significantly improved

pre-service teachers' use of cooperative learning strategies, deep learning, and confidence in teaching science. Also, Akerson, Hanson, and Cullen (2007) stated that guided inquiry was effective in improving most secondary teachers' views of nature of science.

In various research studies about guided inquiry teaching practices, the participants specifically noted that working as a group has very crucial role in addition to gaining effective results and understanding (Deckert, Nestor & DiLullo, 1998; Farrell, Moog & Spencer, 1999). In the study conducted by Farrell et al., (1999), half of the students stated that one of the strengths of this guided inquiry is to use of groups in developing learning and understanding, and for teaching. Thus, these contributions of guided inquiry practices are very critical for some teachers teach science to elementary students more often and effectively than others (Plourde, 2002).

There are, therefore, several studies that provide evidence as to the varied benefits of using a guided inquiry approach in pre-service instruction. Those benefits may either be offset or augmented by the effect that guided inquiry instruction has on pre-service teachers' science teaching self-efficacy beliefs. This study aims to determine the effect of a guided inquiry on pre-service elementary teachers' self-efficacy beliefs in science teaching.

The following research questions were investigated:

1. What is the effect of a guided inquiry used in science laboratory course on pre-service elementary teachers' science teaching personal efficacy and outcome expectancy beliefs?
2. What are the pre-service teachers' opinions about their personal teaching and outcome expectations in science teaching after completing their science laboratory course?

METHODOLOGY

A mixed method approach was used in this study that included a pretest-posttest one group model and semi-structured focus group discussions. The study was conducted with three classes of pre-service teachers who were registered in a science laboratory course during the daytime in the 2008 Spring semester. In the study, it was not compared whether or not the guided inquiry teaching method was more effective than any other methodology. Instead, the focus was on whether or not the pre-service teachers improved their sense of science teaching self-efficacy beliefs after they took science laboratory course in their second year in the program. To develop a method that is compatible with past research in this area, the authors used several attributes of other studies, modifying them to fit the present context. Therefore, these studies, which focused on different aspects of science teacher self-efficacy, provide a coherent body of literature to which the present study contributes. Specifically, the authors modified the design used by Palmer (2006), Plourde (2002), Watters and Ginns (1995), and Wingfield and Ramsey (1999). The result is a mixed-method design in which data were collected using pre-test and post-tests with interviews (Palmer, 2006; Watters & Ginns, 1995; Wingfield & Ramsey, 1999) and written comments on questionnaires (Wingfield & Ramsey, 1999) of pre-service teachers.

Several factors led to the one-group design. First, the use of guided-inquiry instruction is already considered as the most appropriate approach to science teacher preparation. Therefore, the goal of the research was to consider whether guided-inquiry instruction contributes to higher levels of science teaching self-efficacy when it is determined *a priori* to be the instructional approach of choice. There is, so to speak, no acceptable alternative approach to the guided-inquiry approach. However, were the results of this study to demonstrate that guided-inquiry instruction undermines science teacher self-efficacy beliefs, there would be cause to more seriously consider alternative approaches. Further, the one-group design was used in response to the practical reality that

students in the sample were in the position to interact and communicate extensively throughout the term of the project as they work together on assignments in shared classes and across classes. These interactions would present an extraneous variable that could not be controlled. That is, students in one group could potentially affect the science self-efficacy of students in the other groups by sharing experiences that either encouraged or discouraged the other pre-service teachers' self efficacy believes. More specifically with respect to the potential influence of their ongoing communication during the study, the pre-service teachers had many opportunities to share the theoretical knowledge they collected for their activity report sheets.

As part of the data collection, focus group interviews were used in order to gather more detailed information about whether or not exposure to a guided-inquiry teaching method improved their self-efficacy beliefs after completing the science laboratory course. Data collected by using the *STEBI* instrument (Science Teaching Efficacy Belief Instrument) was used in coordination with the focus group interviews.

a) Participants

This study was conducted with the second year students in their fourth semester at the elementary teacher training program at Uludağ University in the city of Bursa in the academic year 2007-2008. There were 30 (29.7%) male and 71 (70.3%) female pre-service teachers. These participants were selected using purposive sampling on the basis of convenience. Although 123 students were registered for this course, only 101 participated in the study. Because some of the participants did not attend that particular class, not all of them completed both pre and post STEBI instruments data. However, all of the participants reflected a willingness to participate. The pre-service teachers were aged between 19 and 23 years, and 93% of them came from a mathematics and literacy background.

b) Description of Science Laboratory Course

The course entitled Science Laboratory is one of the required courses in the second year and fourth semester of the elementary teacher training program. The suggested teaching time for the course is 14 weeks, and the presumed time for the course instruction is one theoretical and two application lessons for a total of 3 hours per week. The science laboratory course is the participants' first required practical science course in the program. The reason for this is that the course provides an opportunity to put into practice participants' knowledge from previous theoretical science courses, such as general chemistry, basic physics, environment, and life-sciences. Therefore, the participants were very active as groups during the class time while they were engaging the activities that assigned. The students were required to take a midterm and final exam to pass the course in addition to the scores they took from the activity reports.

c) Content of Instruction

At the beginning of the semester the participants were in permanent self-selected groups of four or five. One of the classes was taught by the first author, and the other two taught by the second author. Both authors followed exactly the same guided inquiry instruction procedures. For example, the same hands-on activities and theoretical information were applied during the class period. The instructors introduced and explained to their students how to fill out activity report sheets. It was required that participants investigate the theoretical background knowledge about each particular activity of the

following weeks. The pre-service teachers collected theoretical background knowledge either from a library or Internet as groups and recorded this information into the related section of their activity report sheets. In addition, the researchers checked whether or not students had completed this requirement at the beginning of each class period.

As discussed earlier, the current study used a guided inquiry, as an instruction method for pre-service teachers. For this purpose, a lesson plan based on this method was adapted from Martin (1997), where 12 steps were proposed in the lesson plan for elementary science lessons. Instead, 8 of them were used and reorganized for the level of second year pre-service elementary teachers. These steps were as follows:

1. What do I want participants to discover: It was determined that participants were expected to interpret the results of each hands-on activity by using their theoretical knowledge and the data they collected.

2. Scientific processes addressed: At the beginning of each class period, one-hour theoretical instruction about each science process skill was explained by the researchers in detail. These science process skills were observing, measuring, inferring, predicting, communicating, defining operationally, identifying and controlling variables, formulating hypotheses, collecting data, and experimenting.

3. Description of introductory activity: Before the pre-service teachers started to practice hands-on activities in the application period, detailed information on directions and safety rules about activities were presented by the instructors.

4. Materials needed: Necessary materials were provided to the groups at the beginning of the application period.

5. Detailed procedural information about activities: Some details were explained, such as what the participants would practice, how they would collect data, organize the data, draw a graph, and interpret the graphs.

6. Typical discussion questions: Groups were asked typical questions to stimulate their thinking toward the activity objective. For example, what would happen if you increased the number of paper clips attached to the tail of a paper helicopter? And, what would affect the flying time of the paper helicopter?

7. Application to real life situations: After participants completed the hands-on activities, they were asked, "what if type" questions that would help them apply the knowledge they gained to real life situations. For example, during the activity of "observing yeast under the microscope" the question would have been "Why do you think bread dough rises when you added sugar and warm water into the dry yeast?" Or, for the "let's make a siphon activity; one would ask, "Have you ever thought how your siphon works in your bathroom?"

8. Expected conclusions: Participants reported their interpretations of hands-on activities and conclusions in their activity report sheets by using theoretical background knowledge they collected at the beginning. Group members shared responsibilities during the process of filling out activity report sheets. While one group member was reporting the information, other members helped each other organize the final conclusions and comments.

Groups submitted the sheets to the course instructor at the end of the each class period. All groups in three classes completed 9 chemistry, 8 biology, and 17 physics activities in the science laboratory course throughout the semester. Approximately, 2-3 activities were carried out per class time in all three groups. For the examples of physics, chemistry and biology experiments please see Appendix.

d) Data Sources

In this study, data was gathered from two main sources: STEBI (Self-Efficacy Beliefs Instrument) and focus group interviews. Detailed information about the data collection tool and interviews are presented below.

Self-Efficacy Beliefs Instrument: This instrument developed by Enochs and Riggs (1990) was applied as pre and posttest to determine participants' levels of self-efficacy beliefs to make sure if there is a difference between before and after instruction. STEBI included two scales designed for pre-service teachers: (1) personal science teaching efficacy belief scale (13 items for self-efficacy determination) and (2) science teaching outcome expectancy scale (10 items for outcome expectancy dimension). The questionnaire was composed of 23 five choice, Likert-type questions. Alpha reliability coefficients of the self-efficacy dimension and outcome expectancy dimension were found to be 0.90 and 0.76 respectively.

The Turkish adaptation and validation of the instrument was carried out by Bıkmaz (2004). Bıkmaz (2004) found the coefficient for the 13-item science teaching efficacy belief scale was found to be 0.78 while the alpha for the 7-item science teaching outcome expectancy scale was found to be 0.60. For the first dimension, she found construct validity accounted for 18.87% and for the second dimension 11.22% of the variance. A 20-Likert-type scale was composed of 11 positively and 9 negatively written questions. Each item was responded to using a scale of 1-5 (1=strongly disagree; 2= disagree; 3= uncertain; 4= agree; and 5= strongly agree).

In this scale for the first dimension (self–efficacy), possible overall scores could range from 13 to 65 and for the second dimension (outcome expectancies), from 7 to 35. According to this scale, a personal science teaching efficacy belief dimension was evaluated according to the 13-65 level (1=Poor, if the item's mean score ranged from 13.00 to 23.40; 2= Weak, if the item's mean score ranged from 23.53 to 33.80; 3= Neutral, if the item's mean score ranged from 33.99 to 44.20; 4= Good, if the item's mean score ranged from 44.33 to 54.60; and 5=Excellent, if the item's mean score ranged from 54.79 to 65.00). Similarly by using this scale, the science teaching outcome expectancy dimension was judged. according to the 7-35 level (1=Poor, if the item's mean score ranged from 7.00 to 12.60; 2= Weak, if the item's mean score ranged from 12.67 to18.20; 3= Neutral, if the item's mean score ranged from 18.27 to 23.80; 4= Good, if the item's mean score ranged from 23.87 to 29.40; and 5= Excellent, if the item's mean score ranged from 29.47 to 35.00).

Focus Group Interviews: At the end of the instruction, 10 groups of students were randomly chosen out of 26 groups for additional discussions. This method was used for two reasons: first, the participants carried out hands-on activities as groups during the semester, and secondly, it was believed that in addition to the quantitative data, opinions and perceptions of the participants should quite valuable for the focus of investigation, yielding useful information about their science teaching self-efficacy beliefs as it was mentioned before.

Focus group interviews were carried out by two researchers with one group at a time in a quiet place of the department. The researchers took turns and asked specifically two questions to each group:

1. Do you think that there is a difference between your self-efficacy beliefs in teaching science before and after you took this course?

2. How do you think you will use the knowledge you have gained from this course in future?

The authors asked the questions to whole groups. Students, who had answers to these questions, shared their ideas. In other words, not every student in the groups had to answer each question. However, these other students stated whether or not they agreed to their group mates' ideas. A digital camera was used to record answers and to transcribe the collected data. Each group interview took approximately 20-25 minutes.

e) Data Analysis

Quantitative data were analyzed by using paired sample t-test with an SPSS 16.00 program at the .01 significance level. In order to analyze the qualitative data from focus group interviews, a constant comparison method (Lincoln & Guba, 1985; Strauss & Corbin, 1990) was used. After the pre-service teachers' answers were transcribed by the first author, the second author read all the answers as a whole and ensured whether or not questions were understood correctly. Then, the author highlighted the sentences that specifically included meaningful answer to each question. The related answers were classified and copied into another word document, and organized according to each question. By doing this, the researcher determined the illustrative quotations from each group's answers under each question. For some cases, there was more than one quotation that might have been appropriate for inclusion in this paper. If so, the researcher read these quotations many times and chose the clearest ones as the illustrative examples from student group answers. Each participant's answers were read many times until no more additional information emerged from their responses.

FINDINGS

a) Quantitative Findings of STEBI

For the first research questions, descriptive statistics involving means and standard deviations were used to determine science teaching self-efficacy beliefs levels and a paired sample t-test was used to determine whether there was a statistically significant difference between the pre and posttest results. The results according to the instrument's dimensions are presented in Table 1.

Table 1. *Descriptive Statistics for Pre and Posttest Scores*

Self-efficacy belief dimensions	N	Mean	SD	Level
Pre-self-efficacy dimension	101	44.33	4.99	Good
Post-self-efficacy dimension	101	49.36	5.27	Good
Pre-outcome expectancy dimension	101	22.92	2.74	Neutral
Post-outcome expectancy dimension	101	25.78	2.41	Good

These results indicated that participants' pretest (x= 44.33) and posttest (x= 49.36) self-efficacy means were found to be at an *good level* when considering that possible overall scores could range from 13 to 65 for the self-efficacy dimension. However, while the pretest *outcome expectancy* mean results (x= 22.92) are at the *neutral level*, posttest (x=25.78) results are found in *good level* (possible scores 7-35). As it is seen in Table 1 posttest scores for both self-efficacy and outcome expectancy dimensions were higher than pretest scores.

The paired sample t- test results revealed that levels of both self-efficacy beliefs ($t_{(1-100)}$= -9.84, $p<0.01$) and outcome expectancy ($t_{(1-100)}$=-9.18, $p<0.01$) of the participants' were significantly higher than the scores before instruction. The results presented in Table 2.

Table 2. *Paired Sample t- test Results*

Self-efficacy belief dimensions	SD	t	p
Pre and post test self-efficacy dimension	5.18	-9.84	.00*
Pre and posttest outcome expectancy dimension	3.13	-9.18	.00*

*p<0.01

b) Qualitative Analysis of the Focus Group Interviews

For the second research question the interview data was analyzed qualitatively to determine pre-service teachers' ideas and perceptions about self-efficacy and outcome expectancies in science teaching after they completed the course. In the focus group interviews, participants were asked if their self-efficacy beliefs were changed positively or negatively after they completed the science laboratory course. They were also asked how they would benefit from the guided inquiry practiced in this course when they became in-service elementary teachers.

Participants' answers to each question were similar. Descriptive quotations based on interview questions are also provided for each. The most common themes and descriptive quotations are summarized in Table 3. In the table all the names of participants are pseudonyms.

Table 3. *Most Common Themes and Descriptive Quotes of Pre-service Teachers as Extracted from the Interviews*

Q1. Do you think that there is a difference in your self-efficacy beliefs in teaching science before and after you took this course?	
The most common answer	**Descriptive Quote**
1. Did not have any hands-on activity experience in earlier education years	I did not have any teacher who implemented hands-on activities in the science courses in my previous education years. (Bilgen, group 2).
2. Science laboratory course had many hands-on activities which helped to increase self-efficacy	Science was always taught with abstract concepts to us. This situation caused negative self-efficacy beliefs toward science. However, because we learned science by doing in this course, this helped us to have meaningful learning and enjoy the course. (Habibe, group 4).
3. Having mathematics and literacy background that caused a sense of low self-efficacy in teaching science.	I already had a low sense of self-efficacy because of having a mathematics and literacy background. The courses like physics and chemistry were always very abstract areas for me. But this course was very helpful because we practiced the activities. Before I took this course I had some concerns about teaching science, but I believe that I can be capable from now on. (Duygu, group 4)
4. In spite of having knowledge of science concepts, still have *a low sense of self-efficacy before they took this course.*	I have a science background from high school. In fact I was thinking that I had enough science background to teach science. But when I learned what I needed to know, I understood that I did not have a strong background. I did not know how to teach science to children. In this course I learned how to make hands-on activities for children. (Tuğçe, group 3).
5. Positive change after the course. Changing of feelings from being incapable to teach science to students to more sufficient at the end.	I definitely have benefited from this course. I was thinking that I can not teach science to students any more. I think I can. (Zuhal, group 8).
Q2. How do you think that you will use the knowledge you have gained from this course?	
The most common answer	**Descriptive Quote**
1. Hands-on activities practiced in the course were not difficult. They can be practiced with students.	The activities we implemented in this course can easily be remembered when we become teachers. They are not difficult. Therefore, I think I can practice these activities with my students when I became a real teacher. For example, the paper helicopter activity was both fun and interesting to practice with kids. (Gamze, group 1)
2. Abstract concepts was changed	I believe that this course will be very helpful in the future. Abstract concepts became more meaningful in this course. We also can find other activities for our students. (Özlem, group 2)

Table 3. *Continued…*

3. Learning by doing was helpful for implementing the same activities with elementary students.	Because we learned by doing, I am assuming that we can not forget these ideas easily. I believe that these activities would be very effective for elementary students. (Behiye, group 3)
4. Teaching science is not always expensive!	We may not have a lot of materials in schools to teach science. But, some activities we learned in this course do not really require expensive materials to teach some concepts. For example, for the paper helicopter activity, we will only need a piece of paper and paper clips. Also, for Bernoulli principle activities, we will need ping-pong balls, paper, and a plastic tube, etc. (Mehmet, group 5)
5. Definite willingness to teach science with the hands-on activities practiced in this course.	I think I can implement the activities we learned in this class with my students. Everything was visual in this class. I liked these activities. I would practice them in my own class. I am sure kids would love them. (Hasan, group 7)
6. Learning importance of making hands-on activities and experiments in this course.	I definitely have learned how important making hands-on activities and experiments are to students in science. (Gönül, group 9)
7. Willingness to practice guided inquiry caused meaningful learning of abstract concepts	The activities we practiced were all fun. I think these activities will get students' attention in science classes. I believe I can practice the same method [a *guided inquiry*] in my own classroom. In addition, these are the activities that help meaningful learning of some difficult to learn concepts. Therefore, I would like to repeat the same activities in my science class with my students. (Beyhan, group 6).

DISCUSSION and CONCLUSION

In the current study, a guided inquiry, which is one of the factors that have a potential to increase self-efficacy beliefs of pre-service teachers, was investigated at early stages of teacher training programs. Prior to the instruction, while the self-efficacy dimension was at the *good* and outcome expectancy was in *neutral level*, at the end of 14 weeks of instruction, both dimensions were at the *good level*. Also, the findings of paired samples t-tests analysis showed that participants' scores of both self-efficacy beliefs and outcome expectancy were significantly higher than pretest scores.

In addition, focus group interviews show that almost all of the participants had a low sense of self-efficacy beliefs in teaching science before they took the course. Several reasons were reported in focus group interviews by pre-service teachers. Participants stated that they had a limited number of science related courses they took in their high school years. Even some of the pre-service teachers who have science backgrounds in high school said that science was taught in a theoretical way instead of using hands-on practical/experimental activities. Participants also mentioned that the number of hands-on activities they experienced in their previous years was not sufficient; or, they thought these activities were not successful in terms of meaningful learning.

Participants stated that they were satisfied taking a science laboratory class this semester, since they practiced many hands-on activities based on a guided inquiry and this

caused meaningful learning of abstract concepts and enjoyment. They also said that they might practice these activities with their students in the future, since their self-efficacy beliefs in science teaching increased. They specifically pointed out that they would not hesitate to repeat similar science activities when they became in-service teachers. They believed that they could practice many activities by using cheap and simple materials easily found in their school environments. Participants' interview answers also showed that they were willing to practice lesson plans with their own students similar to the plan they experienced based on a guided inquiry. In this regard, these pre-service teachers can easily translate their positive experiences to their own students' learning in future. These findings are parallel with the suggestions of Bursal (2008) that hands-on science activities are effective to develop students' attitudes towards science and science teaching. Furthermore, the results of this study are consistent with the study conducted by Watters and Ginns (1995) that negative high school experiences are related to low sense of personal science teaching self-efficacy and that could be developed if the students could get support and be engaged in suitable learning environments. Similarly, the sense of outcome expectancies of pre-service teachers could also be enhanced with successful field experiences with students in classrooms. Participants stated that they had a low sense of self-efficacy in teaching science, before took the science laboratory course. However, their posttest results showed a higher sense of self-efficacy for both dimensions. This finding is consistent with previous research both by Palmer (2006) and Utley et. al. (2005). It is thought that using hands-on activities based on a guided inquiry helped them to realize that they could actually teach science.

In the study the most common answers of participants were consistent with pre-school teacher candidates' answers in the study conducted by Vural and Hamurcu (2008). Their findings indicated that the participants, who were in their first and third years of teacher training programs, also had a low sense of self-efficacy for teaching science. The pre-service teachers highlighted several reasons for this. They thought that the number of science related courses they took in teacher training programs were not sufficient to build strong science content knowledge. The content of the science methods courses they took did not include hands-on activities. Therefore, students stated that they really would like to learn hands-on laboratory procedures in science related courses in teacher preparation programs. Finally, because teacher candidates come from different high school backgrounds, the ones who have mathematics and literacy backgrounds might have a lower sense of self-efficacy compared to the candidates who have science backgrounds (Vural & Hamurcu, 2008). These reasons are exactly the ones that participants in this current study mentioned in the focus group interviews**.**

There are two inconsistencies between the study conducted by Bursal (2008) and the current study. It was believed that the pre-service teachers' personal science teaching self-efficacy beliefs should be determined in early years of teacher training programs. In addition, unlike the findings of Bursal (2008), Moseley et. al., (2002), and Plourde (2002), all groups of pre-service teachers improved their scores after guided inquiry was applied in the science laboratory course.

Consequently, both qualitative and quantitative results of the current study indicated that pre-service teachers' self-efficacy beliefs could be improved by appropriate teaching approaches, such as *a guided inquiry*. However, in our study it was found that the posttest results of participants were not at *excellent level.* Therefore, science methods courses and field experiences in the third and fourth years of teacher training program appear to be significantly important for achieving better outcomes of self- efficacy beliefs in science teaching.

The current study suggests that focus group interviews provided a window into pre-service teachers' personal ideas about experiencing *a guided inquiry* with various science activities in their science method courses. In addition to using the measurement tool (STEBI), interviews helped the researchers to triangulate the data. The quantitative and qualitative elements provided mutually supporting evidence in this study. With only the quantitative part of the study the researchers would not have had an opportunity to fully understand participants' ideas about the science laboratory course. Conversely, with only the qualitative part of the study, they could not have learned whether or not pre-service teachers improved their sense of self-efficacy beliefs in teaching science after they took this course.

In this study, the level of self-efficacy beliefs of pre-service teachers in science teaching was investigated in the second year of their teacher training programs, which is earlier than many previous studies did. This provides a diagnostic tool for determining what should be changed in their subsequent courses to improve students' likelihood of success in their future teaching careers. Then, a guided inquiry was practiced in their science laboratory course where the lesson plan proposed by Martin (1997) for elementary science lessons was adapted to Turkish context. However, in the current study this new adapted lesson plan was practiced for Turkish elementary pre-service teachers in a science laboratory course. It is hoped that the way the lesson plan used in this study can increase the sense of self-efficacy beliefs of pre-service teachers in science teaching. For this reason, it is recommended that more research is needed to determine the effects of a guided inquiry on pre-service teachers' science teaching self-efficacy beliefs.

SUGGESTIONS

It is appear that in order to teach science effectively, elementary school teachers need to have a high sense of self-efficacy beliefs. To accomplish this goal, science course instructors for teacher training programs should adopt a guided inquiry in their science laboratory courses and into real classroom situations for improved the pre-service teachers' sense of self-efficacy beliefs in science teaching. It is obvious that as in-service teachers of future, current pre-service teachers should practice this type of methods in their teacher training programs.

Longitudinal studies are also needed to determine whether or not these same participants' self-efficacy beliefs change after they take a science methods course in their third year and then after two years of teaching. Because the science methods course is quite important for them to learn many methodologies in teaching science, the effect of this course could be significant for increasing self-efficacy beliefs and ultimately, improved student learning of science. Or, even in their fourth year, one could look at the effect in their field experiences in terms of their performance in teaching science.

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APPENDIX

I. AN EXAMPLE OF PHYSICS ACTIVITY

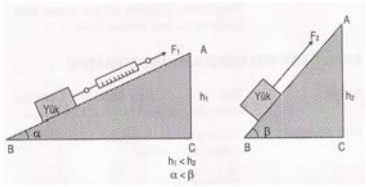
HOW THE HEIGHT OF INCLINED PLANE AFFECTS WEIGHT OF AN OBJECT?

GOAL

To develop an understanding of how the height of inclined plane affects the weight of object read from dynamometer.

MATERIALS

- Board to make an inclined plane (approximately 15 cm width)
- A wooden block
- Books (to prop board)
- A dynamometer
- A piece of rope
- A ruler



FOCUSING QUESTIONS

1. Why do we feel tired while we are climbing a ramp?
2. Do you know what simple machines are?
3. Why do you think we prefer to use simple machines in our daily lives?
4. Why do we prefer to use an inclined plane when we want to lift up heavy weights from the ground? Could you give any examples from your own experiences?

PROCEDURE

1. Make an inclined plane by using three or four books and a board and measure the height with a ruler.
2. Weight the wooden block with a dynamometer in the air and record the value.
3. Tie a piece of rope to the wooden block, attach them on a dynamometer, and pull them along the inclined plane.
4. Read the value of the dynamometer while you are pulling the objects on the inclined plane and compare the second value with the first one.
5. Repeat the steps for up to 5, 6, or 7 books in height for the inclined plane. Re-measure the heights every time when you increase. Record the new weight values once to read dynamometer after each try.

EVALUATION QUESTIONS

1. What were the dependent, independent, and constant variables for this experiment?
2. Is there any differences between the values you read from the dynamometer in the air and on the ramp?
3. What happened to the weight of the wooden block as the ramp got steeper? Which one did take more effort to move?
4. Have you seen that an inclined plane helped to make your job easier as a simple machine?
5. What kind of gain did you have when you used inclined plane?

II. AN EXAMPLE OF CHEMISTRY ACTIVITY

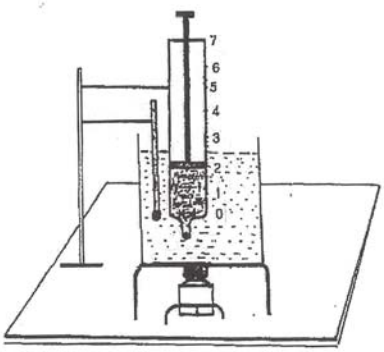
CHARLES' LAW

GOAL

To determine how the volume of a gas changes when the temperature changes.

MATERIALS

- Beaker
- Thermometer
- 5 milliliter Syringe
- Hot plate
- Clamp
- Clay



FOCUSING QUESTIONS

1. How temperature does affect the kinetic energy of gas molecules?
2. Please state dependent, independent, and constant variables for this experiment.

PROCEDURE

1. Add enough water in a beaker to prepare a water bath.
2. Fill the syringe until two milliliter with air and close tightly tip of syringe with clay.
3. Put the syringe to the water bath. Clamp the syringe in a beaker of water set up to be heated
4. First, measure the temperature of the water. (This temperature should be the temperature of the gas inside the syringe).
5. Start heating water bath and measure and record volume of air in syringe up to 90 ^{o}C.

EVALUATION QUESTIONS

1. Graph your results by using volume of air and the temperature (^{o}C) as variables.
2. How would you evaluate your graph?
2. Using your graph, how do you think volume and temperature of a gas related?
3. What is the effect of the temperature on the volume?
4. What is the V/T ratio every time when you change the temperature?
5. Have you been able to prove the Charles Law with this experiment?

III. AN EXAMPLE OF BIOLOGY ACTIVITY

WHICH GAS IS BREATH OUT DURING RESPIRATION?

GOAL

To determine which gas do green plants breathe out after respiration.

MATERIALS

- Germinated green peas
- Erlenmeyer's balloon with wide mouth (500 ml)
- A test tube
- Glass tube
- Plastic corks with two holes (they need to be fit into 500 ml Erlenmeyer's balloon)
- Funnel
- Drinking straw
- Clamp
- Chalky water

FOCUSING QUESTIONS

1. Do you think green plants breathe?
2. Should we keep green plants during the daytime in the living room? Why?
3. Should we keep green plants during the nighttime in the bedroom? Why?

PROCEDURE

1. Put germinated green peas in one of the 500 ml Erlenmeyer's balloons (approximately one third of erlen's volume)
2. Fill the test tube with tap water.
3. Close one hole of the cork with clamp. Make sure there is a funnel at the top of the clamp. 4. Place the apparatus to a dark environment
5. Wait one week and replace the tap water with chalky water.
6. Open the clamp of the funnel and add some tap water into the funnel slowly.
7. Observe the changes of the color of the chalky water.
8. Breathe out into chalky water which is found in another test tube.

EVALUATION QUESTIONS

1. What happened to the chalky water?
2. What does the reaction indicates?
3. Which gas do you think is collected from the test tube? And why?
4. Which life event was proved in this experiment?