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Preservice Teachers' Science Process Skills and Science Teaching Efficacy Beliefs in an Inquiry-Oriented Laboratory Context

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ABSTRACT

This study investigated (i) the effect of inquiry-oriented laboratory activities on preservice primary school teachers' (PPSTs) achievement in science process skills (SPS) and science teaching efficacy beliefs, and (ii) changes in groups' reflections of SPS in the laboratory reports as they engaged in the activities. There were 71 PPSTs enrolled in a science laboratory course. Of the 71 PPSTs, 61 who completed the Science Process Skills Test and Teachers' Sense of Efficacy Scale both at the beginning and at the end of the course constituted the sample for the former purpose of the study. On the other hand, 71 PPSTs formed groups to work on the laboratory activities and reports collaboratively, which resulted in a total of 17 groups that were involved in the study for the latter purpose. Findings indicated that PPSTs' achievement in SPS and reflections of SPS in the reports improved in the inquiry-oriented laboratory environment. Furthermore, experiencing the intervention contributed to PPSTs' science teaching efficacy beliefs for instructional strategies, student engagement, and classroom management. Implications for teacher education programs and recommendations for future research are presented.

Keywords: inquiry-oriented laboratory instruction, science process skills, teacher efficacy, science teaching, preservice teachers

Introduction

Science process skills (SPS) are a set of skills that reflect scientists' behaviors when doing science (Padilla, 1990). They are commonly divided into two as basic and integrated. Basic SPS, such as observing, measuring, inferring, classifying, communicating, and predicting, form a basis for learning integrated SPS, which are more complex, such as controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models (Padilla, 1990). Improving students' SPS has been a major goal of science education due to these skills' vital role in students' science learning (Harlen, 1999). At this point, inquiry-oriented science instruction seems to be a substantial way of developing students' SPS (e.g., Akben, 2015; Koksal & Berberoglu, 2014) because inquiry enables learners to engage in scientific investigation (Bybee, 2006).

Although inquiry has long been encouraged to be used in science classes, there are still deficiencies in teachers' use of inquiry-based activities. One problem in implementation of inquiry-based teaching is regarding teachers' perceptions of laboratory activities; teachers should not only aim to promote students' acquisition of science concepts but also improve students' SPS through these inquiry-based laboratory activities (Akben, 2015). Teacher education programs promoting preservice teachers' practicing inquiry-based activities may help them improve approaches to inquiry activities and ensure proper use of inquiry activities in their own classrooms (Bhattacharyya et al., 2009). Previous research also documented preservice teachers' shortcomings in their own SPS (e.g., Maral et al., 2010; Mbewe et al., 2010). It can be speculated that in order to provide their future students with inquiry-oriented activities, preservice teachers need to experience inquiry-oriented activities during their teacher education programs and develop their own SPS. Considering these, the first purpose of this study was to explore how inquiry-oriented laboratory instruction influences preservice primary school teachers' (PPSTs) achievement in SPS and reflections of SPS in the laboratory reports.

To achieve a desired level of science teaching, in addition to content knowledge and pedagogy, teacher training needs to focus on teachers' efficacy beliefs (Bhattacharyya et al., 2009). Teacher efficacy is teachers' judgments about their abilities to accomplish teaching related tasks (Tschannen-Moran et al., 1998). Indeed, "beliefs are far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behavior" (Pajares, 1992, p. 311). Thus, what teacher education programs should do to foster preservice teachers' science teaching efficacy beliefs should be illuminated (Morrell & Carroll, 2003).

Several studies focused on the effect of inquiry-based instruction on teacher efficacy beliefs within the context of various courses in preservice teacher education programs other than science laboratory course (e.g., Liang & Richardson, 2009; Menon, 2020; Menon & Sadler, 2016; Palmer, 2006; Soprano & Yang, 2013), but few studies examined its effect in laboratory course (Kıran, 2022; Özdilek & Bulunuz, 2009; Şen & Sezen Vekli, 2016). Therefore, there is a need to investigate how inquiry-based laboratory instruction influences preservice teachers' science teaching efficacy beliefs. We propose that not being familiar with the requirements of inquiry-oriented laboratory environment PPSTs may struggle initially. However, as the treatment progresses they may display successful performance in inquiry-oriented laboratory activities which, in turn, may contribute to their appraisals of science teaching abilities. Thus, the second purpose of this study was to investigate the effect of inquiry-oriented laboratory instruction on PPSTs' science teaching efficacy beliefs for instructional strategies, student engagement, and classroom management.

Inquiry-Oriented Science Instruction and its Relation with SPS

Inquiry-oriented science is a major part of educational reform (Alake-Tuenter et al., 2012). According to National Science Education Standards, even students in grades K-4 can ask questions, do simple investigations, use tools to gather data, construct explanations based on the data, and communicate their investigations and explanations. Thus, these students should be given an opportunity to experience active construction of ideas and doing science through inquiry (National Research Council, 1996).

Depending on the information provided to students, there are four levels of inquiry instruction that range from being more teacher directed to more student centered: confirmation, structured inquiry, guided inquiry, and open inquiry (Rezba et al., 1999, as cited in Bell et al., 2005). In confirmation, students are provided with a question, procedure (methods), and expected outcomes (solution), such as verification of a concept in the laboratory after the concept has been taught. In structured inquiry, students engage in a prescribed procedure to answer a teacher posed question. In guided inquiry, the teacher still poses a question but the procedure to be followed for the investigation is determined by students. On the other hand, in open inquiry, students formulate their questions and choose their methods for the investigation. According to students' readiness level, the teacher utilizes the appropriate level of inquiry instruction and as students practice inquiry, they should steadily progress toward higher levels of inquiry (Bell et al., 2005).

Previous research generally indicated that inquiry-oriented science instruction improved students' SPS (e.g., Idul & Caro, 2022; Koksal & Berberoglu, 2014; Mulyeni et al., 2019; Roth &

Roychoudhury, 1993). For example, in a study with second grade elementary school students (Mulyeni et al., 2019), structured and confirmatory inquiry were implemented by using the 5E learning model. Quantitative data analysis revealed that as a result of the implementation process, students' basic SPS of observation, classification, and measurement improved significantly. Qualitative data analysis indicated that hands-on activities, completing worksheets, interaction between students and students, and students and teachers, and observing the teacher and peers while using SPS all contributed to students' development of SPS. In a recent study (Idul & Caro, 2022), the effect of process-oriented guided inquiry learning, in which students work in small groups and collaborate during inquiry, was investigated on high school grade 10 students in a biology class. It was found that process-oriented guided inquiry learning developed students' academic performance in biology, overall SPS, and specifically SPS of observing, classifying, and inferring. There is also evidence for positive effects of inquiry-oriented instruction on preservice teachers' SPS (e.g., Karışan et al., 2016; Yakar & Baykara, 2014). For instance, Karışan et al. (2016) found that PPSTs' SPS increased as a result of reflective inquiry-based science laboratory activities. Another study showed that laboratory activities based on argument-driven inquiry improved preservice science teachers' SPS more than traditional laboratory activities (Demircioglu & Ucar, 2015). However, most of the prior studies measured SPS through achievement tests and calculated total scores and did not give information about specific skills. On the other hand the present study, in addition to exploring SPS as a whole, focused on each of SPS separately. PPSTs' reflections of particular skills were investigated through laboratory reports.

Teaching Efficacy Beliefs and their Relationship with Inquiry-Oriented Science Instruction

Teacher efficacy is teachers' judgments of their capabilities to operate teaching functions (Tschannen-Moran et al., 1998). Teachers' efficacy beliefs influence their goals, enthusiasm, and behavior in the classroom, such as how much effort they exert (Tschannen-Moran et al., 1998). Previous studies showed that teachers' efficacy is closely related to teacher behavior, student behavior, and student achievement (e.g., Ashton & Webb, 1986; Ross, 1992).

In this study, we followed Tschannen-Moran and Woolfolk Hoy's (2001) three dimensional conceptualization which comprises efficacy for instructional strategies, classroom management, and student engagement. Accordingly, efficacy for instructional strategies is related to teachers' beliefs that they can adjust their lesson for the proper level of students, provide alternative explanations when students are confused, and use a variety of assessment strategies. Efficacious teachers for classroom management, on the other hand, believe that they can control disruptive behavior in the classroom and get children to follow classroom rules. Lastly, efficacy for student engagement refers to teachers' beliefs that they can motivate their students and help students value learning. Teachers' efficacy beliefs are context specific, meaning their efficacy is not the same for all school subjects or for all student levels (Tschannen-Moran et al., 1998). In the present study, PPSTs' efficacy specific to teaching primary school science was the focus.

When efficacy beliefs are formed, it is difficult to change them (Tschannen-Moran et al., 1998). Therefore, promoting the efficacy beliefs of preservice teachers is an important role of teacher education programs (Yerdelen et al., 2019). Research provided evidence for the effectiveness of inquiry-based instruction on preservice teachers' teaching efficacy beliefs of science (e.g., Bhattacharyya et al., 2009; Liang & Richardson, 2009). Although most of the previous studies were conducted within the context of a teaching practice course (e.g., Bhattacharyya et al., 2009; Soprano & Yang, 2013), science methods course (e.g., Palmer, 2006; Seung et al., 2019), or science content course (e.g., Liang & Richardson, 2009; Menon & Sadler, 2016), a few studies were carried out in a laboratory course (Kıran, 2022; Özdilek & Bulunuz, 2009; Şen & Sezen Vekli, 2016). For instance, Özdilek and Bulunuz (2009) investigated the effect of inquiry activities in the laboratory course on preservice teachers' science teaching efficacy beliefs. At the beginning of each class, the course instructor explained one of the SPS. Then, prior to hands-on activities, preservice teachers were given detailed information on directions and procedures such as how they would collect and organize data. Findings of the study showed that participants' teaching self-efficacy beliefs improved; however, their levels of efficacy were not at an excellent level. In Şen and Sezen Vekil's (2016) study, the effect of an inquiry approach was investigated in a general biology laboratory-one course with a sample of preservice science teachers. These authors found that at the end of the semester, SPS and laboratory usage self-efficacy beliefs of students in the experimental group instructed with an inquiry-based approach were higher than those of students in the control group instructed with a traditional teaching approach. These studies provide empirical evidence for the support of inquiry-based laboratory activities on preservice teachers' science teaching self-efficacy beliefs and laboratory teaching self-efficacy beliefs. However, the effect of inquiry-oriented laboratory instruction on preservice teachers' science teaching efficacy for instructional strategies, student engagement, and classroom management were not addressed in these studies. In a recent study, Kıran (2022) dealt with this issue, and investigated how preservice science teachers' teaching efficacy beliefs for instructional strategies, student engagement, and classroom management are affected by inquiry-based laboratory activities. The study lasted 14 weeks; three weeks for introducing laboratory rules and organization, three weeks for inquiry instruction and science process skills, and the rest of the weeks included open inquiry laboratory activities. It was found that every dimension of teaching efficacy beliefs of preservice science teachers improved at the end of the semester when compared with the beginning of the semester. We think that providing preservice teachers with a gradual transition for student-centered inquiry activities, namely introducing them firstly with structured inquiry and then with guided inquiry, may be helpful for preservice teachers to get accustomed to this approach. Therefore, there is a need to conduct more studies in order to illuminate the effect of inquiry-oriented instruction employed in the science laboratory course on preservice teachers' science teaching efficacy.

Purpose and Research Questions

This study investigated the influences of inquiry-oriented laboratory instruction. More specifically, it focused on how this intervention affects (i) PPSTs' achievement in SPS and science teaching efficacy beliefs and (ii) groups' reflections of SPS in the laboratory reports. The following research questions (RQs) were addressed:

1. What is the effect of inquiry-oriented laboratory instruction on PPSTs' achievement in SPS?
2. What is the effect of inquiry-oriented laboratory instruction on PPSTs' science teaching efficacy for instructional strategies, student engagement, and classroom management?
3. How do groups' reflections of SPS in the laboratory reports change as they engage in inquiry-oriented laboratory activities?

Method

Design

This study comprised two parts. In the first part, one-group pretest-posttest design was employed to investigate the effect of inquiry-oriented laboratory instruction on PPSTs' achievement in SPS and beliefs of science teaching efficacy (RQ1 and RQ2). The inquiry-oriented laboratory instruction was undertaken within the context of a science laboratory course. The Science Process Skills Test (SPST; Burns et al., 1985) and Teachers' Sense of Efficacy Scale (TSES; Tschannen-Moran & Woolfolk Hoy, 2001) were administered to PPSTs to measure their achievement in SPS and science teaching efficacy beliefs, respectively both at the beginning and at the end of the course. To evaluate the effect of the inquiry-oriented laboratory instruction, PPSTs' pre- and post-treatment scores were compared through paired-samples t-tests. In the second part, qualitative research was utilized to inspect changes in groups' reflections of SPS in the laboratory reports as PPSTs engaged in inquiry-oriented laboratory activities (RQ3). The groups' laboratory reports were analyzed with regard to the groups' reflections of SPS through qualitative data analysis.

Participants

There were 71 PPSTs (46 females, 25 males; 61 sophomores, 10 upper graders) enrolled in a science laboratory course at a public university in the Central Anatolia region of Türkiye[1]. Of the 71 PPSTs, 61 (42 females, 19 males) who completed quantitative data collection instruments both at the beginning and at the end of the course constituted the sample in the first part of the study. On the other hand, 71 PPSTs formed groups of 3-5 members to work on the laboratory activities and reports collaboratively. This resulted in a total of 17 groups that were involved in the second part of the study.

The Context of the Study: A Science Laboratory Course

The science laboratory course was a must course offered in the third semester of primary teacher education programs. The course lasted for 13 weeks, had two sections both taught by the first author, and each section met weekly for a two-hour block.

The course began with instruction of issues including safety in the laboratory, laboratory equipment and materials, and SPS. Then, it proceeded with six laboratory activities related to various science topics: The first activity was a preparatory activity, and the following five activities were inquiry-based activities. PPSTs were informed about the focus of the week beforehand, and in general at the start of each class, a quiz was given with the aim of ensuring PPSTs' preparation for the class. PPSTs worked in groups on the laboratory activities and associated reports. That is, PPSTs worked in groups and designed and/or performed the activities, collected data, and completed the reports through answering the questions with regard to the activities and reflecting on the SPS employed during the activities. The laboratory report sheet was provided to groups at the beginning of each activity and was required to be returned at the end of the class. The instructor monitored groups' work, guided them to do inquiries, evaluated the laboratory reports, and gave feedback to the groups about their comprehension and performance regarding the activities and their use and reflections of SPS.

The Laboratory Activities and Associated Reports

The science laboratory course comprised six laboratory activities. The laboratory activities and associated reports were prepared by utilizing related textbooks (e.g., Arslan et al., 2015) and/or previous research (e.g., Ozdem et al., 2013). The first activity was a preparatory activity to accustom PPSTs to performing an activity and completing an associated report in groups, experiencing certain SPS, and reflecting the skills in the report. More specifically, the activity was related to using a light microscope. Initially, a mini instruction was given to PPSTs about parts, magnification, and usage of a light microscope. Then, they were asked to find images of specimens using prepared slides and

[1] This study did not cause any physical or psychological harm to the participants. The participants were informed about the purpose of the study and were told that they could withdraw from the study on any occasion. The participants' names were not used in the study; a number was given to each data collection instrument to ensure anonymity.

answer the questions in the given laboratory report (e.g., “Draw the images of the object you are examining when the objectives of 4x and 40x are used and write down your observations”). On the other hand, the subsequent five activities were inquiry-based, and these five activities were the focus of the present study. Activities one through five hereafter refer to inquiry-based activities. Activities one and two were in line with structured inquiry in which PPSTs were provided with an implied research question and a procedure. For example, in activity one, PPSTs were asked to detect characteristics of a letter’s (e.g., “R”) image on a light microscope. PPSTs were also directed through the procedure with questions given in the related laboratory report (e.g., “How was the image of the letter you examined on the light microscope compared to the letter on the stage?”, “Write your observations about the image when the slide was moved to the left, right, backward, and forward”). Activities three through five were congruent with guided inquiry in which PPSTs designed the procedure to be followed to answer the research question given/implied by the instructor. For example, in activity four, PPSTs were asked to design and perform an experiment to explain the relationship between the force exerted on a spring and the extension of the spring. The reason for preferring this sequence was that the course was the first course on science laboratory that PPSTs had taken, and they were not accustomed with inquiry-oriented instruction. Also, during the activities, PPSTs were encouraged to employ a range of SPS and reflect the skills in the reports. Table 1 informs about the laboratory activities and associated reports along with targeted SPS.

Table 1

The Inquiry-Based Laboratory Activities and Associated Reports Along with Targeted SPS

Laboratory activities	**Targeted SPS**		**Descriptions of laboratory activities and reports**
1. Examination of a letter’s image through a light microscope	Predicting Observing Recording data	Communicating Interpreting data	PPSTs detected characteristics of a letter’s (e.g., “R”) image on a light microscope.
2. Inspection of samples through a stereo microscope	Predicting Observing Recording data	Communicating Interpreting data Classifying	PPSTs detected characteristics of an image on a stereo microscope by inspecting samples including a piece of paper with inscription, sand, sugar, salt, and an insect and identified the ways (using top or bottom lighting) to have a clear image.
3. Examination of a plant cell and an animal cell through a light microscope	Predicting Observing Recording data	Communicating Interpreting data Classifying	PPSTs found the images of an onion peel cell and a human cheek epithelial cell and detected the difference in shape between the two cells.
4. Relation between the force exerted to a spring and the extension of the spring	Observing Measuring Formulating a hypothesis Identifying and controlling variables Defining operationally Designing and conducting an experiment	Recoding data Communicating Constructing a table of data Constructing a graph Interpreting data	PPSTs explored the relationship between the force exerted to a spring and the extension of the spring.
5. Density	Observing Measuring Identifying and controlling variables Designing and conducting an experiment Recording data	Communicating Constructing a table of data Constructing a graph Interpreting data	PPSTs explored the relationship between the amount of water and its density and identified the density of an irregularly shaped solid.

Measures

Science Process Skills Test (SPST)

The SPST was developed by Burns et al. (1985) to measure middle and high school students' achievement in integrated SPS. It is a 36-item multiple-choice test with items referring to SPS of identifying variables, operationally defining, stating hypotheses, graphing and interpreting data, and designing investigations. Burns et al. (1985) found the coefficient alpha for the test as .86. The SPST was translated and adapted into Turkish by Geban et al. (1992) who reported the reliability coefficient as .81. Considering Burns et al.'s (1985) view that besides measuring secondary students' SPS achievement, the SPST may be convenient for use in teacher education programs. Considering research that drew on the SPST with data collected from preservice teachers (e.g., Bozkurt, 2014), this study employed the SPST to measure PPSTs' SPS achievement. In this study, pre-treatment and post-treatment test scores yielded satisfactory internal consistency coefficients computed by Kuder-Richardson 20, which were .60 and .83, respectively.

Teachers' Sense of Efficacy Scale (TSES)

The TSES was developed by Tschannen-Moran and Woolfolk Hoy (2001) for gauging teacher efficacy. There are two forms of the scale: a 12-item short form and a 24-item long form. The scale includes three subscales: efficacy for instructional strategies, efficacy for student engagement, and efficacy for classroom management with each subscale having four items in the short form and eight items in the long form. Sample items of efficacy for instructional strategies, student engagement, and classroom management are as follows respectively: "To what extent can you use a variety of assessment strategies?", "How much can you do to get students to believe they can do well in schoolwork?", and "How much can you do to control disruptive behavior in the classroom?". The items are scored on a nine-point scale (1= nothing, 3= very little, 5= some influence, 7= quite a bit, and 9= a great deal).

The long form of the TSES was adapted into Turkish by Çapa et al. (2005) who revealed the reliability and validity of scores acquired from Turkish preservice teachers. Then, Yerdelen (2013) provided reliability and validity evidence for the short form of the scale with Turkish inservice science teachers. Considering that the short form is more advantageous in terms of usability, and it is not more disadvantageous in terms of reliability and validity, the short form was employed in this study. Although the TSES was developed for gauging general teacher efficacy, there are also studies that utilized the TSES to measure science teaching efficacy beliefs (e.g., Kıran, 2022; Yerdelen, 2013). Similar to these studies, and in the current study, the wording of the items in the scale was modified to explore science teaching efficacy. For instance, the item, "To what extent can you use a variety of assessment strategies?", was modified as "To what extent can you use a variety of assessment strategies in science courses?". In the present study, the scale yielded satisfactory reliability with Cronbach's alpha values ranging from .72 to .85 (pre-treatment) and ranging from .66 to .82 (post-treatment).

Laboratory Reports

The five laboratory reports associated with the previously mentioned, inquiry-oriented laboratory activities were utilized to assess changes in groups' reflections of SPS as they engaged in the activities. In addition to guiding PPSTs to complete the activities through inquiry, the questions in the reports directed PPSTs to employ certain SPS and reflect the skills in the reports. More specifically, there were questions associated with particular SPS that required PPSTs to perform the skills (for detailed information see data analysis). Also, each report was comprised of a question which asked PPSTs to elucidate SPS that they employed throughout the activity.

Data Analysis

Data analysis included two parts. In the first part, PPSTs' pre- and post-treatment SPST scores were compared through a paired-samples t-test. To create pre- and post-treatment SPST scores, correct responses given to the items on the SPST were coded with a one, while incorrect responses and responses left blank were coded as zero. Then, scores given to each item on the SPST were summed. Besides, PPSTs' pre- and post-treatment scores for subscales of teaching efficacy beliefs were compared through paired-samples t-tests. Pre- and post-treatment subscale scores were computed by averaging scores given to the items belonging to each subscale.

In the second part, responses in the laboratory reports to the question which asked to elucidate SPS that PPSTs employed throughout the activity and/or to the question associated with the particular skill were evaluated. While accurate responses were scored as one, inaccurate responses and responses left blank were scored as zero. For a response to be considered as accurate, PPSTs were expected to state the name of the skill that they experienced during the activity and provide its explanation by relating the skill with the activity. For formulating a hypothesis, identifying and controlling variables, defining operationally, designing and conducting an experiment, constructing a table of data, and constructing a graph, in addition to the aforementioned criteria, PPSTs' responses to the question related to the particular skill were checked for accuracy. More specifically, to get a score of one for "formulating a hypothesis", groups should provide the name of the skill along with its explanation in relation to the activity and construct a testable hypothesis. For example, Group 13 properly stated and elucidated the skill they experienced during activity four as "Formulating a hypothesis: The potential solution we offered for the experiment" and formulated the hypothesis "As the force exerted to the spring increases, the amount of the spring extension increases". In comparison, Group five responded as "We formulated the hypothesis that different masses affect the length of the spring differently" which was considered as inaccurate because the group did not correctly state the independent variable and did not explicitly specify how the independent variable affected the dependent variable. Table 2 demonstrates sample quotes of groups' responses which were considered as inaccurate and accurate for each of SPS.

While analyzing reports, initially the first author assigned scores. Then, the first and second author went over the responses and scores and discussed the ambiguous parts. Consequently, this resulted in agreed scores along with associated responses.

Table 2

Sample Quotes of Groups' Inaccurate (Score = 0) and Accurate (Score = 1) Responses for Each of SPS

SPS	Score	Sample quote
Predicting	0	"Predicting" (G8-A1) [The group did not provide an explanation of the skill in relation to the activity]
	1	"Predicting: We predicted about how onion peel and epithelial cells would look like" (G6-A3) [The group made predictions about the images of both cells in response to the related question]
Observing	0	"Since we observed objects in terms of shape and color, we made a quantitative observation." (G15-A3) [The group inappropriately labeled the observation as quantitative]
	1	"Observing: We observed the shape and color of the substances we examined. A qualitative observation was made" (G13-A2)
Recording data	0	"Recording data: We prepared a laboratory report." (G1-A4) [The group did not provide an adequate explanation of the skill in relation to the activity]
	1	"Recording data: We recorded the amount of the spring's extension" (G16-A4)
Communicating	0	[All of the groups that got the score of 0 did not identify "communicating" as a response to the related question]
	1	"Communicating: We discussed how to prepare a microscope slide as a group" (G3-A1)
Interpreting Data	0	"Interpreting data: As group members, we compared and interpreted the data each of us obtained" (G16-A3) [The group did not provide an adequate explanation of the skill in relation to the activity. More specifically, the group did not mention about the conclusion group members drew]
	1	"Interpreting data: We interpreted the data we obtained. Drawing a conclusion: We drew a conclusion in line with the data we obtained and the hypothesis we tested: The amount of substance does not affect the density." (G11-A5) [Since interpreting data comprises arranging data and forming conclusions from the arranged data (Padilla, 1990), the group's response was accepted as accurate]
Classifying	0	"Classifying: We analyzed transparent, translucent, and opaque materials by classifying them." (G12-A2). [The group did not classify the materials; the mentioned classification already existed in the related question. The question was that "Considering that the sand is opaque; salt and sugar are translucent; and the insect wing is transparent, discuss with your group friends what kind of lighting is used for each of them".]
	1	[None of the groups provided an accurate response]
Measuring	0	"Measuring: We measured the density of stone and water" (G7-A5) [The density was not measured; it was calculated by using a formula]
	1	"Measuring: We found the masses of the materials (stone, graduated cylinder, graduated cylinder filled with water) to be used in the experiment using a balance. Using graduated cylinder, volumes of water and volumes of 'water + stone' were found" (G14-A5)
Designing and conducting an experiment	0	"Conducting an experiment" (G10-A5) [The group reported only the name of the skill; did not provide an explanation of the skill in relation to the activity]
	1	"Designing and conducting an experiment: We designed the experiment according to the hypothesis we formed and carried out the experiment." (G1-A4) [In response to the related question in the report, the group provided an appropriate design to examine the relation between the force exerted to a spring and extension of the spring]
Identifying and controlling variables	0	"Identifying and controlling variables: We identified and controlled variables throughout the experiment." (G1-A5) [In response to the related question in the report, the group gave an incorrect response by identifying dependent variable as volume and mass of liquid]
	1	"Identifying and controlling variables: We identified dependent and independent variables. We kept other variables constant so that another variable other than the independent variable we specified did not affect the result (controlling)" (G17-A4) [In response to the related question in the report sheet, the group identified the independent variable as the force exerted to a spring (weight), the dependent variable as amount of extension of the spring, and controlled variables as tripod base, metal rods, fixing apparatus, kind of wire, thickness of wire, and length of wire.]

Table 2 *Continued*

SPS	Score	Sample quote
Constructing a table of data	0	[All of the groups that got the score of 0 did not specify “constructing a table of data” as a response to the related question]
	1	“Constructing a table: We constructed a mass-density table.” (G3-A5) [The group provided an appropriate mass-density table in response to the related question]
Constructing a graph	0	“We constructed our graph according to the results of the experiment.” (G4-A5) [Although independent and dependent variables were mass of water and density of water respectively, the group constructed a volume-density graph, which is not exactly congruent with variables of the activity]
	1	“Constructing a graph: We constructed a mass-density graph.” (G3-A5) [The group provided an appropriate mass-density graph in response to the related question]
Formulating a hypothesis	0	“We formulated the hypothesis that different masses affect the length of the spring differently” (G5-A4) [The group did not correctly state the independent variable and did not explicitly specify how the independent variable affected the dependent variable]
	1	“Formulating a hypothesis: The potential solution we offered for the experiment.” (G13-A4) [In response to the related question in the report, the group formulated an appropriate hypothesis which was that “As the force exerted to the spring increases, the amount of the spring extension increases”.]
Defining operationally	0	“Defining operationally: We made the operational definition of the variables.” (G10-A4) [The group’s operational definition of the dependent variable was that “variable that changes depending on the independent variable”, which is not appropriate because it did not include information about how the variable was measured]
	1	“Defining operationally: We identified the variables and defined how to measure and observe the variables.” (G17-A4) [The group operationally defined the dependent variable, that is extension of the spring, as “measuring the change in the length of the spring depending on the independent variable through a ruler”]

Note. ‘G’ and ‘A’ refer to group and activity, respectively.

Results

Effect of the Intervention on PPSTs’ Achievement in SPS

PPSTs’ scores on the SPST were utilized as indicators of their achievement in SPS. Participants’ average pre-treatment SPST score was found as 19.84 out of 36, demonstrating a moderate level of achievement in SPS. On the other hand, the average SPST score increased to 27.74 on the post-treatment test, suggesting a high level of achievement. To investigate whether there was a significant change in PPSTs’ average SPST score after inquiry-oriented laboratory instruction, a paired-samples t-test was conducted. The paired-samples t-test resulted in a statistically significant increase in PPSTs’ achievement in SPS following the treatment, and an eta square (η^2) value demonstrated a large effect size (Cohen, 1988). See Table 3 for this information.

Table 3

Descriptive Statistics for SPST Scores and Paired-Samples t-test Results

	Pretest		Posttest		Gain score (posttest-pretest)	SE	t	df	p	η^2
	M	SD	M	SD						
SPST	19.84	3.96	27.74	5.23	7.90	0.65	12.23	60	0.00	0.71

Effect of the Intervention on PPSTs' Science Teaching Efficacy Beliefs

PPSTs' scores on the subscales of the TSES were considered as indicators of their science teaching efficacy for instructional strategies, student engagement, and classroom management. Participants attained average pre-treatment scores of 5.80 for efficacy on instructional strategies, 5.75 for efficacy on student engagement, and 6.21 for efficacy on classroom management on a nine-point scale. These average scores suggested a moderate sense of efficacy beliefs. After the treatment, the average scores increased to 6.30 for efficacy on instructional strategies, 6.46 for efficacy on student engagement, and 6.76 for efficacy on classroom management. To evaluate changes in PPSTs' science teaching efficacy beliefs components, three paired-samples t-tests were carried out. Bonferroni adjustment with the reduced alpha level of .017 (.05/3) was applied to decrease the probability of making a type I error. The analysis resulted in a significant increase in all efficacy aspects. An eta square (η^2) value indicated that increase in efficacy for student engagement was large, and medium for instructional strategies and classroom management according to Cohen's (1988) criteria. See Table 4.

Table 4

Descriptive Statistics for Scores of Science Teaching Efficacy Beliefs Subscales and Results of Paired-Samples t-tests

	Pretest		Posttest		Gain score (posttest-pretest)	SE	t	df	p	η^2
	M	SD	M	SD						
Instructional strategies	5.80	1.50	6.30	1.29	0.50	0.16	3.15	60	0.00	0.14
Student engagement	5.75	1.31	6.46	0.92	0.71	0.14	4.93	60	0.00	0.29
Classroom management	6.21	1.28	6.76	1.12	0.54	0.13	4.11	60	0.00	0.22

Changes in Groups' Reflections of SPS in the Laboratory Reports

When groups' responses for each of SPS over the laboratory reports were examined, it was seen that the influence of the intervention on PPSTs' reflections of SPS was not uniform. See Table 5.

Table 5

Total Number of Groups That Provided Accurate Responses for Targeted SPS in the Laboratory Reports

Laboratory Reports	Communicating	Predicting	Designing and conducting an experiment	Constructing a table of data	Recording data	Interpreting data	Measuring
1	7	7	-	-	6	5	-
2	13	15	-	-	5	8	-
3	13	15	-	-	11	9	-
4	14	-	13	11	10	6	11
5	15	-	14	14	14	10	11

Note. "-" indicates that the skill was not addressed in the report.

Table 5 *Continued*

Laboratory Reports	Observing	Constructing a graph	Defining operationally	Formulating a hypothesis	Identifying and controlling variables	Classifying
1	10	-	-	-	-	-
2	17	-	-	-	-	0
3	14	-	-	-	-	0
4	12	12	8	13	10	-
5	10	10	-	-	4	-

Note. "-" indicates that the skill was not addressed in the report.

More specifically, as PPSTs engaged in the laboratory activities, the number of successful groups mostly increased, and to a lesser extent decreased, or remained the same. For SPS of communicating, predicting, designing and conducting an experiment, and constructing a table of data, the number of groups that were accomplished in the last report, in which the skill was included, was greater than that in the first report in which the skill was addressed. For these skills, as the treatment progressed, the number of accomplished groups increased or remained the same. For example, the skill of predicting was targeted in laboratory reports one, two, and three. Seven of the 17 groups gave an accurate response for this skill in laboratory report one. Of these seven groups, five continued their success in all of the subsequent laboratory reports and the rest of the groups (n=2) succeeded in one of the two subsequent reports. The groups that did not answer accurately in laboratory report one (n=10) showed an attainment in laboratory report two and/or laboratory report three. As a result, the total number of groups that gave an accurate response was 15 in each of laboratory reports two and three. For recording data and interpreting data, although the number of successful groups fluctuated over the reports, it was greater in the last report than that in the first report. For measuring and observing, the number of achieved groups in the last report was equal to that in the first report in which the skill was addressed. For observing, initially an increase and then a continuous decrease was detected in the successful groups. However, both skills were accurately reflected in the reports by most of the groups.

Constructing a graph skill was targeted in two of the activities. Although the number of groups that achieved decreased slightly from the first report, in which the skill was targeted to the last report, in both reports more than half of the groups were accomplished. The skills of defining operationally and formulating a hypothesis were addressed in only one activity and slightly less than half and most of the groups respectively accomplished these skills.

On the other hand, the skill of identifying and controlling variables was targeted in two of the activities and although more than half of the groups succeeded in the first report, in which the skill was targeted, a noticeable decrease was observed from the first to the last report. More specifically, 10 of the 17 groups gave an accurate response for this skill in laboratory report four. Among the mentioned 10 groups, three groups maintained their accomplishment in laboratory report five, but other groups (n=7) did not. Of the seven groups that did not respond accurately in laboratory report four, one revealed an achievement in laboratory report five. Totally, only four groups responded accurately in laboratory report five. Additionally, two of the activities addressed classifying skill but none of the groups showed accomplishment.

Discussion

This study assessed how inquiry-oriented laboratory activities affect PPSTs' achievement in SPS and science teaching efficacy beliefs and inspected groups' reflections of SPS in the laboratory reports. Findings showed that PPSTs' achievement in SPS increased substantially following the intervention. When groups' reports were examined, it can be concluded that the intervention was effective -albeit to varying degrees- to improve PPSTs' reflections of most of the targeted SPS. We think that as PPSTs experienced the activities, they had the opportunity to use SPS, hold discussions about the skills within their groups, and reflect on the skills they used during the activities in the reports, all of which supported their comprehension, use, and reflections of SPS. Findings of previous studies also indicated positive influences of inquiry-based instruction on preservice teachers' SPS (e.g., Demircioglu & Ucar, 2015; Karışan et al., 2016), however, the present study extended our understanding by providing evidence about changes in particular SPS through evaluation of laboratory reports.

Although PPSTs' reflections of most of the targeted SPS was promising, this was not the case for two of the skills. For the skill of identifying and controlling variables, a considerable decrease in the number of achieved groups was detected from the first report, in which the skill was targeted, to the last report and none of the groups succeeded at the skill of classifying in the reports. Accordingly, it can be inferred that the activities of inspecting samples through a stereo microscope and examining the cells through a light microscope were insufficient for supporting PPSTs' reflections of classifying skill. In a similar vein, the activity about density was inadequate for underpinning PPSTs' reflections of identifying and controlling variables skill. Hence, the aforementioned activities should be improved to promote PPSTs' reflections of the skills of classifying and identifying and controlling variables. We suggest that selection of activities to be used in the science laboratory is important and more activities which address the skills of classifying and identifying and controlling variables can be incorporated to overcome deficiencies at these skills. Mastery of SPS is essential for science teaching and in order to get expertise, preservice teachers should develop a sound understanding of SPS, and practice these skills, in the guidance of university programs (Ango, 2002).

This study also revealed that being exposed to the intervention, PPSTs felt more efficacious about instructional strategies, student engagement, and classroom management. Gaining experiences in an inquiry-oriented laboratory context contributed to PPSTs' efficacy beliefs about how to provide explanations to students who are confused about science concepts, evaluate students' science learning, engage students with a science course, motivate students to learn science, and manage class in the science course. As the treatment progressed, PPSTs showed generally more successful performance in the activities as evidenced in the reports and their SPSs improved which, in turn, might raise their appraisals of science teaching abilities. Previous research findings also suggested that inquiry promoted the development of preservice teachers' efficacy beliefs (e.g., Liang & Richardson, 2009; McCall, 2017; Palmer, 2006; Seung et al., 2019; Soprano & Yang, 2013) and cultivating mastery experiences fosters self-efficacy (Zientek et al., 2019). However, most of the prior studies were conducted within the context of teaching practice, science methods, or science content courses, while the present study supported its positive effects within the context of a science laboratory course. As mentioned before, a few studies (i.e., Özdilek & Bulunuz, 2009; Şen & Sezen Vekli, 2016) examined the effect of inquiry-based laboratory instruction on preservice teachers' science teaching and laboratory teaching self-efficacy beliefs and demonstrated positive effects. To our knowledge, one study (Kıran, 2022) investigated the effect of open inquiry-based laboratory activities on preservice teachers' efficacy beliefs for instructional strategies, student engagement, and classroom management. It was found that at the end of the semester preservice teachers' efficacy beliefs improved in all three dimensions. Findings of the current study support Kıran's (2022) findings and extend these findings such that positive effects were also attained with structured and guided inquiry activities. Science laboratory has an important role in science education, such as the development of students' understanding of science concepts and how science works (Hofstein & Mamlok-Naaman, 2007). In an inquiry-oriented laboratory course, preservice teachers have opportunity both to study subject matter and practice inquiry (Kıran, 2022) and incorporating both content and method has the potential to improve teaching efficacy beliefs of preservice teachers (Deehan et al., 2019). Thus, we think that PPSTs' gaining experience in an inquiry-oriented laboratory environment and improving their science teaching efficacy beliefs within this context are important for their future teaching practices.

Based on the findings of the present study, we suggest that in teacher education programs, PPSTs can be provided with opportunities to experience inquiry-oriented instruction and a science laboratory course seems to be very appropriate for this purpose. Laboratory activities designed and performed in accordance with inquiry-based instruction appeared to support PPSTs' achievement in and reflections of SPS and beliefs of science teaching efficacy. Therefore, it is worthwhile for teacher education programs to employ an inquiry approach in training prospective teachers.

Limitations of the Study and Recommendations for Future Research

This study has some limitations that need to be clarified and some recommendations for future research. First, findings of this study demonstrated increases in PPSTs' achievement in SPS and science teaching efficacy beliefs after attending the intervention. However, this does not mean that the intervention caused these increases; other factors that have affected the results may exist (see Fraenkel et al., 2012). Future studies can include a comparison group to argue for causality more strongly. Second, further studies can include individual interviews with PPSTs to attain in-depth information about their understanding of SPS. Third, the present research was limited to five laboratory activities designed and implemented in compliance with structured inquiry and guided inquiry. We recommend future research to include inquiry-oriented activities enabling preservice teachers to experience open inquiry as well. Fourth, there were 13 total SPS addressed in the activities and their presence varied. Since formulating a hypothesis and defining operationally were addressed in only one activity, it is not possible to investigate changes in groups' reflections of these skills in the reports. In addition to this, a small number of activities may not be adequate for promoting PPSTs' comprehension of the targeted skill and for assessing groups' reflections of the skill. In future studies, the targeted skills can be addressed in more activities.

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References

Akben, N. (2015). Improving science process skills in science and technology course activities using the inquiry method. *Education and Science, 40*(179), 111-132. https://doi.org/10.15390/EB.2015.4266

Alake-Tuenter, E., Biemans, H. J., Tobi, H., Wals, A. E., Oosterheert, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: A literature study and critical review of the American National Science Education Standards. *International Journal of Science Education, 34*(17), 2609-2640. https://doi.org/10.1080/09500693.2012.669076

Ango, M. L. (2002). Mastery of science process skills and their effective use in the teaching of science: An educology of science education in the Nigerian context. *International Journal of Educology, 16*(1), 11-30.

Arslan, O., Bahar, M., & Özel, Ç. A. (2015). *Genel biyoloji laboratuvar kılavuzu [General biology laboratory guide]*. Palme Yayıncılık.

Ashton, P., & Webb, R. (1986). *A study of teachers' sense of efficacy: Final report, executive summary*. National Institute of Education.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction. *The Science Teacher*, *72*(7), 30-33.

Bhattacharyya, S., Volk, T., & Lumpe, A. (2009). The influence of an extensive inquiry-based field experience on pre-service elementary student teachers' science teaching beliefs. *Journal of Science Teacher Education, 20*(3), 199-218. https://doi.org/10.1007/s10972-009-9129-8

Bozkurt, E. (2014). *Mühendislik tasarım temelli fen eğitiminin fen bilgisi öğretmen adaylarının karar verme becerisi, bilimsel süreç becerileri ve sürece yönelik algılarına etkisi* [The effect of engineering design based science instruction on science teacher candidates' decision making skills, science process skills, and perceptions about the process] [Doctoral thesis, Gazi University]. Council of Higher Education Thesis Center. https://tez.yok.gov.tr/UlusalTezMerkezi/giris.jsp

Burns, J. C., Okey, J. R., & Wise, K. C. (1985). Development of an integrated process skill test: Tips II. *Journal of Research in Science Teaching, 22*(2), 169-177. https://doi.org/10.1002/tea.3660220208

Bybee, R. W. (2006). Scientific inquiry and science teaching. In L. B. Flick & N. G. Lederman (Eds.), *Scientific inquiry and nature of science: Implications for teaching, learning, and teacher education.* (pp. 1-14). Springer.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Erlbaum.

Çapa, Y., Çakıroğlu, J., & Sarıkaya, H. (2005). The development and validation of a Turkish version of teachers' sense of efficacy scale. *Education and Science, 30* (137), 74-81.

Deehan, J., McKinnon, D. H., & Danaia, L. (2019). A long-term investigation of the science teaching efficacy beliefs of multiple cohorts of preservice elementary teachers. *Journal of Science Teacher Education, 30*(8), 923–945. https://doi.org/10.1080/1046560X.2019.1672377

Demircioglu, T., & Ucar, S. (2015). Investigating the effect of argument-driven inquiry in laboratory instruction. *Educational Sciences: Theory & Practice, 15*(1), 267-283. https://doi.org/10.12738/estp.2015.1.2324

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education*. (8th ed.). McGraw-Hill.

Geban, O., Askar, P., & Ozkan, I. (1992). Effects of computer simulated experiments and problem solving approaches on high school students. *Journal of Educational Research, 86*, 5-10. https://doi.org/10.1080/00220671.1992.9941821

Harlen, W. (1999). Purposes and procedures for assessing science process skills. *Assessment in Education: Principles, Policy & Practice, 6*(1), 129–144. https://doi.org/10.1080/09695949993044

Hofstein, A., & Mamlok-Naaman, R. (2007). The laboratory in science education: The state of the art. *Chemistry Education Research and Practice, 8*(2), 105-107. https://doi.org/10.1039/B7RP90003A

Idul, J. J. A., & Caro, V. B. (2022). Does process-oriented guided inquiry learning (POGIL) improve students' science academic performance and process skills?. *International Journal of Science Education, 44*(12), 1994-2014. https://doi.org/10.1080/09500693.2022.2108553

Karışan, D., Bilican, K., & Şenler, B, (2016). Yansıtıcı sorgulamaya dayalı laboratuvar etkinliklerinin sınıf öğretmen adaylarının bilimsel süreç becerilerine etkisinin incelenmesi [Investigation of the effects of reflective inquiry based laboratory activities on primary school teachers' science process skills]. *YYÜ Eğitim Fakültesi Dergisi* [YYU Journal of Education Faculty], *13*(1), 123-145.

Kıran, D. (2022). Examining the efficacy change of preservice science teachers: does an inquiry-based laboratory instruction make a difference? A mixed method study. *International Journal of Science Education, 44*(9), 1527-1548. https://doi.org/10.1080/09500693.2022.2084171

Koksal, E. A., & Berberoglu, G. (2014) The effect of guided-inquiry instruction on 6th grade Turkish students' achievement, science process skills, and attitudes toward science, *International Journal of Science Education, 36*(1), 66-78. https://doi.org/10.1080/09500693.2012.721942

Liang, L. L., & Richardson, G. M. (2009). Enhancing prospective teachers' science teaching efficacy beliefs through scaffolded, student-directed inquiry. *Journal of Elementary Science Education, 21*(1), 51-66.

Maral, S., Oguz-Unver, A., & Yurumezoglu, K. (2010). The tendencies and difficulties experienced by pre-service science teachers during basic measuring. *Procedia-Social and Behavioral Sciences, 2*(2), 2189-2193. https://doi.org/10.1016/j.sbspro.2010.03.305

Mbewe, S., Chabalengula, V., & Mumba, F. (2010). Pre-service teachers' familiarity, interest and conceptual understanding of science process skills. *Problems of Education in the 21st Century, 22*, 76-86.

McCall, M. (2017). Elementary preservice science teaching efficacy and attitude toward science: Can a college science course make a difference? *Electronic Journal of Science Education, 21*(6), 1-11.

Menon, D. (2020). Influence of the sources of science teaching self-efficacy in preservice elementary teachers' identity development. *Journal of Science Teacher Education, 31*(4), 460-481. https://doi.org/10.1080/1046560X.2020.1718863

Menon, D., & Sadler, T. D. (2016). Preservice elementary teachers' science self-efficacy beliefs and science content knowledge. *Journal of Science Teacher Education, 27*(6), 649-673. https://doi.org/10.1007/s10972-016-9479-y

Morrell, P. D., & Carroll, J. B. (2003). An extended examination of preservice elementary teachers' science teaching self-efficacy. *School Science and Mathematics, 103*(5), 246-251. https://doi.org/10.1111/j.1949-8594.2003.tb18205.x

Mulyeni, T., Jamaris, M., & Supriyati, Y. (2019). Improving basic science process skills through inquiry-based approach in learning science for early elementary students. *Journal of Turkish Science Education, 16*(2), 187-201.

National Research Council. (1996). *National science education standards.* NationalAcademy Press.

Ozdem, Y., Ertepinar, H., Cakiroglu, J., & Erduran, S. (2013). The nature of pre-service science teachers' argumentation in inquiry-oriented laboratory context. *International Journal of Science Education, 35*(15), 2559-2586. https://doi.org/10.1080/09500693.2011.611835

Özdilek, Z., & Bulunuz, N. (2009). The effect of a guided inquiry method on pre-service teachers' science teaching self-efficacy beliefs. *Journal of Turkish Science Education, 6*(2), 24-42.

Padilla, M. J. (1990). The science process skills. *NARST: Publications - Research Matters - to the Science Teacher*. https://narst.org/research-matters/science-process-skills

Pajares, F. M. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307–332.

Palmer, D. (2006). Durability of changes in self-efficacy of preservice primary teachers. *International Journal of Science Education, 28*(6), 655-671. https://doi.org/10.1080/09500690500404599

Ross, J. A. (1992). Teacher efficacy and the effects of coaching on student achievement. *Canadian Journal of Education, 17*(1), 51-65. https://doi.org/10.2307/1495395

Roth, W. M., & Roychoudhury, A. (1993). The development of science process skills in authentic contexts. *Journal of Research in Science Teaching, 30*(2), 127-152. https://doi.org/10.1002/tea.3660300203

Seung, E., Park, S., & Lee, M. A. (2019). The impact of a summer camp-based science methods course on preservice teachers' self-efficacy in teaching science as inquiry. *Journal of Science Teacher Education, 30*(8), 872–889. https://doi.org/10.1080/1046560X.2019.1635848

Soprano, K., & Yang, L. L. (2013). Inquiring into my science teaching through action research: A case study on one pre-service teacher's inquiry-based science teaching and self-efficacy. *International Journal of Science and Mathematics Education, 11*(6), 1351-1368. https://doi.org/10.1007/s10763-012-9380-x

Şen, C., & Sezen Vekli, G. (2016). The impact of inquiry based instruction on science process skills and self-efficacy perceptions of pre-service science teachers at a university level biology laboratory. *Universal Journal of Educational Research, 4*(3), 603-612. https://doi.org/10.13189/ujer.2016.040319

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783-805. https://doi.org/10.1016/S0742-051X(01)00036-1

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202-248. https://doi.org/10.3102/00346543068002202

Yakar, Z., & Baykara, H. (2014). Inquiry-based laboratory practices in a science teacher training program. *Eurasia Journal of Mathematics, Science & Technology Education, 10*(2), 173-183. https://doi.org/10.12973/eurasia.2014.1058a

Yerdelen, S. (2013). *Multilevel investigations of students' cognitive and affective learning outcomes and their relationships with perceived classroom learning environment and teacher effectiveness* [Doctoral dissertation, Middle East Technical University]. Council of Higher Education Thesis Center. https://tez.yok.gov.tr/UlusalTezMerkezi/giris.jsp

Yerdelen, S., Osmanoglu, A., & Tas, Y. (2019). The influence of a teaching practice course with video-case enriched microteaching on prospective teachers' self-efficacy for teaching. *International Journal of Research in Education and Science, 5*(2), 560-573.

Zientek, L. R., Fong, C. J., & Phelps, J. M. (2019). Sources of self-efficacy of community college students enrolled in developmental mathematics. *Journal of Further and Higher Education, 43*(2), 183-200. https://doi.org/10.1080/0309877X.2017.1357071