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Examining the Effects of Reflective Journals on Pre-Service Science Teachers' General Chemistry Laboratory Achievement

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Abstract: The general chemistry laboratory is an appropriate place for learning chemistry well. It is also effective for stimulating higher-order thinking skills, including reflective thinking, a skill that is crucial for science teaching as well as learning. This study aims to examine the effects of feedback-supported reflective journal-keeping activities on first-year pre-service science teachers' achievement. The pre-service science teachers were observed for eight weeks by collecting their journals. At the beginning and end of this process, an achievement test was administered. At the end of the study, the participants were also interviewed. It was found that feedback-supported reflective journal-keeping activities improved the first-year pre-service science teachers' achievement scores, and the majority of the participants believed that the activities had positive effects on their meta-cognition and learning.

Introduction

Laboratory experiences play a central role in the teaching and learning of science. They are very effective in increasing students' comprehension of scientific concepts; stimulating interest and motivation towards the subject; developing scientific process and problem solving skills; understanding the nature of science; and promoting the transfer of scientific knowledge into daily life skills (Hoftsein & Lunetta, 2004). Chemistry, which is one of the sub-branches of the sciences, involves a great number of abstract concepts. Therefore, laboratory applications have special importance with respect to students' comprehension of chemistry (Ayas, Karamustafaoğlu, Sevim, & Karamustafaoğlu, 2002; Herrington & Nakhleh, 2003). Chemistry laboratory applications are effective for helping learners to comprehend chemical definitions and equations well and to transfer them to long-term memory. In addition, laboratory experiences ensure that students are interested in learning chemistry and that they are active in the learning process (Ding & Harskamp, 2011).

Science teacher training program outcomes in faculties of education specify that pre-service science teachers must have adequate laboratory skills in order to utilize laboratory applications in their professional teaching careers. For this reason, it is important for pre-service science teachers to develop their knowledge and skills in chemistry laboratories during their undergraduate education programs (Kırbaşlar, Özsoy Güneş & Deringöl, 2008). However, some studies have made it clear that teachers, pre-service teachers, and other undergraduates have inadequacies in context and application knowledge, as well as self-confidence, with regard to laboratory applications (Coştu, Ayas, Çalık, Ünal, & Karataş, 2005; Kocakülah & Savaş, 2011; Özdem, Ertepınar, Çakıroğlu, & Erduran, 2013; Veal, Taylor, & Rogers 2009). Before this study was conducted, the researchers managed undergraduate general chemistry laboratory-1 (GCL1) and general chemistry laboratory-2 (GCL2) classes at their university. The observations made by the researchers during these

classes indicated that most of the pre-service teachers did not recognize the laboratory equipment; their self-esteem was low in class; and they were not eager to study. It was considered that in order to eliminate these inadequacies, using activities to improve students' thinking skills may provide a significant contribution.

In this sense, educating individuals with well-developed thinking skills is one of the main aims of education (Alkan & Ceylan, 2008; Pithers, & Soden, 2000); reflective thinking is among the higher order thinking skills. This study investigates the effectiveness of reflective journals, a tool noted for improving reflective thinking, on pre-service science teachers' (who will be referred as pre-service teachers in short for the rest of the study) achievement.

Reflective Thinking

Early ideas about reflective thinking come from John Dewey. According to Dewey (1910, as cited in Tok, 2008), reflective thinking is a concept where any thought or knowledge structure is considered actively, continuously and carefully. In the relevant literature, different definitions of reflective thinking are provided. For instance, according to Kim (2005, p.11) reflective thinking "refers to the process of purposeful and conscious activity to monitor, analyse, and evaluate one's own learning in terms of achieving learning goals, sustaining motivation, making deep understanding, using appropriate learning strategies, and interacting with peers and instructors in order to construct new perspectives of learning that directly lead to improve learning process and performance." Similarly, Ünver (2003: 5) defines reflective thinking as "an individual's thinking process towards revealing positive and negative situations in teaching or learning methods and solving problems." Based upon the results of studies researching the effects of reflective thinking on learning *(e.g.*, Amodeo, 1996; Grant, Kinnersley, Metcalf, Pill, & Houston, 2006; Kim, 2005; Mair, 2010; Moffitt, 2000; Park, 2003) reflection on learning is defined as an individual's decision-making and planning in order to learn more effectively by evaluating: (1) the level at which he or she has reached the learning objectives; (2) the learning environment from which he or she has benefited with the aim of reaching these objectives; and the efficiency of learning environment, learning materials and learning methods.

There are many benefits of reflective thinking in teaching and learning. Reflective thinking enables individuals to realize their strengths and weaknesses in the course of thinking deeply about the actions they performed or plan to perform; to form an opinion on how to remove the deficiencies in their actions; and to understand their own and others' thinking processes by watching the efforts of their own interpretations and those of the people around them (Ersözlü, 2008). With reflective thinking, learners can determine how to learn effectively and become responsible for their own learning (Doğan Dolapçıoğlu, 2007).

Reflective thinking is essential for lifelong learning. Learners in higher education are expected to perform reflective thinking in their classes, because this process enables them to take responsibility for their own learning and present their aims and action plans. Individuals who can think reflectively improve their work and organisation skills (Dilci & Babacan, 2012; Mair, 2010; Ünver, 2003). Furthermore, Yorulmaz (2006) points out that, through reflective thinking, learners will eventually realize how they learn best and develop the ability to determine their own learning process. Thus, individuals with better reflective thinking skills are expected to demonstrate higher academic performance. In the following section, an argument is provided about reflective teaching, as well as the features of reflective journals, one of the techniques used for promoting reflective teaching.

Reflective Teaching and Reflective Journals

In a teaching process that will improve reflective thinking skills, a learner has to be an active decision maker, and a teacher should be a facilitator and an encouraging guide (Wilson & Jan, 1993). With reflective teaching, evaluation is process-oriented; learners learn through reflective thinking and constructive methods, and the teacher evaluates the products, plans learning according to learners' deficiencies, and works toward addressing the learners' weak points. Through this process, learning becomes meaningful and permanent (Doğan Dolapçıoğlu, 2007).

In improving reflective thinking skills, activities such as debates about reflective thinking; video recordings; computer-assisted teaching; comprehension-based concept maps; mutual discussion; preparing portfolios; and writing reflective journals are all considered to be effective (Şahin, 2009). These methods maybe combined and used together, or they may be implemented separately according to the nature of the class (Ersözlü, 2008).

In reflective journals, which are one of the most effective methods for improving reflective thinking skills, learners reflect on current learning and teaching activities by keeping a journal. While writing, they think about the learning process; thus, they may recognize how they learn, and they express what they have learned in an original manner. These journals enables to learners participate more actively in their own learning, which leads to permanent learning (Kazu & Demiralp, 2012). Recent research provides evidence that keeping reflective journals helps learners construct meaningful knowledge; practice what they have learned; improve their practices by analysing them constantly; organise their thoughts; realize what they know or do not know about the subject; solve problems; and reduce stres (Cengiz & Karataş, 2013; Kozan, 2007; Lowe, Prout & Murcia; 2013; Moffitt, 2000). Therefore, in addition to their positive effects on learning, reflective journals help improve self-enquiry and meta-cognitive skills (Langer, 2002). Accordingly, in this study, the researchers investigate how writing reflective journals affects pre-service teachers' achievement in a GCL1 class. When the related literature is examined, it can be seen that there are studies about reflective thinking, but a limited number of studies have investigated the effects of reflective journals on students' academic success (Burrow, McNeill, Hubele, & Bellamy, 2001; Kim, 2005; Lee, 2013; Palmer, Holt, & Bray, 2012). For this reason, this study may contribute to the literature as an examination of the relationship between keeping reflective journals and academic success. At the same time, it is considered that determining the pre-service teachers' views about keeping reflective journals on explaining their successes/failures in practice may provide another significant contribution. Thus, in designing this study, it was believed that examining pre-service teachers' views about their laboratory practice, as well as the content of their reflections and the frequencies of their ideas expressed in reflective journals, would effectively propound the relationship between reflective thinking and academic success.

Purpose of the Study

The purpose of this study was to evaluate the effectiveness of feedback-supported reflective journal-keeping activities performed in a General Chemistry Laboratory-1 (GCL1) course on first-year pre-service teachers' achievement. In accordance with the purpose of the study, the following research questions were explored:

1. How does writing reflective journals affect pre-service teachers' achievement in a GCL1 class?

2. What are pre-service teachers' views regarding the efficacy of reflective journal-keeping activities?
3. What the themes emerge from reflective journals kept by pre-service teachers?

Method

In accordance with the aim of the study, the research design was grounded in a case study approach (Stake, 1995). A case study allows researchers to investigate a contemporary phenomenon within its natural setting from a holistic perspective (Harling, 2002), enabling examination of data at the micro level; and generally, a case study method relies on a very limited number of individuals as subjects (Zainal, 2007). Stake (1995) classified the various types of case studies as intrinsic, collective, and instrumental; there sent study falls into the category of instrumental case studies, which provide insight into an issue or help refine a theory (Grandy, 2010). In this study, the effect of reflective journal-keeping activities within a general chemistry laboratory course on pre-service teachers' academic success was probed. Here, examining this effect is more important than the case itself, which means that the case is of secondary interest (Grandy, 2010; Stake, 1995). In order to confirm the validity of the process, triangulating the data through different methods is useful (Zainal, 2007). In this study, the data collection instruments, including reflective journals, interviews, and academic achievement tests, allowed the researchers to examine the case holistically, which is one of the important features of case studies (Harling, 2002).

Setting and Participants

The overall structure of the Turkish educational system consists of formal and non-formal education. Primary, secondary and tertiary education form the basis of formal education. Primary and secondary education are compulsory and consist of three four-year-long modules; elementary school, middle school, and high school. Compulsory education starts with primary education at the age of six years. In the first four years of basic education, an elementary school teacher is responsible for most of the teaching. After elementary school, students enrol in a four-year middle school, where the teachers are specialists in subjects that include science, mathematics, social science, language and so on. In high school, further specialization takes place. For example, physics, chemistry, and biology subjects are separated from the general science that is taught in middle school. Elementary, middle and high school teachers have different pre-service training programmes with different curriculums. The pre-service science teacher training programme that is the subject of this study requires a solid science background in various branches of science, including but not limited to physics, chemistry, biology, astronomy, and environmental science, as well as general pedagogy and pedagogical content knowledge (YÖK, 2007). The pre-service science teacher programme is a four-year-long concurrent programme in which both science and pedagogy courses are taken simultaneously.

This study was conducted in the department of primary education (with divisions of pre-school, elementary school, and middle school) at a large university in the 2012-2013 fall semester with 14 first-year pre-service science teachers. One of the required content knowledge courses in this programme is GCL1; this study was conducted in the context of this course. All of the participants were female. They had not had any education regarding reflective thinking and they had not kept any reflective journals before the study.

The pre-service teachers were taught about laboratory safety rules and first aid procedures at the beginning of the class. There were eight required experiments that needed

to be performed to pass the class. The topics of the experiments and their execution order are as follows:

- examination of heat exchange in the mix of liquids with different heat and mass;
- purification by crystallization;
- sublimation of naphthalene;
- flame test;
- mole concept;
- recognizing acid, bases and salts;
- concentration specification of a solution of which the concentration is not known;
- preparation of solutions.

The pre-service teachers were asked to come to the laboratory prepared for the experiment that would be performed that week. The participants were able to find information on how to perform the experiments in their laboratory manuals. The laboratory manuals also included key concepts associated with the experiments, but the explanations of these concepts were intentionally not presented, as learners were expected to investigate them. A few questions regarding the experiment were placed in the manuals, as well.

The Researchers' Role

The classes were conducted by two teaching assistants. One of the teaching assistants was also one of the researchers involved in this study. Before starting each experiment, the conceptual information about the experiment was discussed with the whole class. The prior knowledge of the pre-service teachers was evaluated by the teaching assistant who conducted the study. Then, the procedure for performing the experiment was explained to the pre-service teachers, and the experiments were performed in groups consisting of four to five participants based on the guidelines provided in the laboratory manual. The other teaching assistant was also actively involved in the stage at which the pre-service teachers performed their experiments. When the pre-service teachers needed assistance (such as having a question or a problem with the experiment), the teaching assistants helped them.

Data Collection

In order to collect the data, reflective journals, an achievement test, and face to face individual interviews were utilized.

Reflective Journals

The pre-service teachers were asked to prepare reflective journals in which they were to reflect on their learning for eight weeks. While writing the journals, a total of 17 guiding questions (see Appendix 1) were presented to the pre-service teachers in order to obtain the benefits of the reflective journals. The pre-service teachers were asked to reflect on one or more of these questions (or any other topics they preferred concerning their learning). Some of these questions are as follows:

- What did you learn about your learning after this class, and how?
- What were your feelings during the learning process? How and why did you feel this way?
- What are the factors that made you feel this way?
- What did this class make you decide to do in the future?

The journals that were prepared by the pre-service teachers were then graded by the researchers. In order to determine the pre-service science teachers' level of reflection, each learning journal was examined and graded from 1 to 4 based on the rubric described in Table 1 (Cengiz, 2011; Moon, 2009).

Degree of Reflection	Description
Descriptive writing	In this account, ideas tend to be linked by the sequence of the account/story rather than by its meaning.
Descriptive account with some reflection	This focuses on the event as if there is a big question but inefficiency in responding to the questions means that there is little actual analysis of the events.
Reflective writing	The explanation contains some analysis and the importance of explaining motives or reasons for behaviour is realized. There is some self-questioning and also willingness to recognize the overall effect of the event on himself/herself.
Advanced reflective writing	The explanation contains deep reflection, and it incorporates awareness that the frame of reference with which an event is viewed can change.

Table 1: Rubric for Levels of Reflective Writing

The scores taken from the journals comprised 10% of the course grades.

Achievement Test

In order to determine the participants' prior knowledge and course achievement concerning the main chemistry topics, an open-ended test was developed (see Appendix 2). A grid matching the educational attainments and test items was developed to ensure the content validity of the test (Karip, 2007). Accordingly, an achievement test consisting of 16 questions regarding the concepts for each experiment was developed by the researchers. A pilot administration of the achievement test was conducted with 27 second-year pre-service science teachers. In order to improve the content, structure, and face validity of the achievement test, the questions were examined by a panel of experts including two chemistry educators, one chemist, and one linguist.

Interviews

An interview protocol was developed and employed in order to examine the pre-service teachers' views about the effectiveness of reflective thinking and keeping reflective journals (Johnson & Christensen, 2014). In the interview protocol, the following question was asked in order to determine the effects of reflective journals on learning: "What kind of effects does keeping a reflective journal have?" A pilot study was conducted with two pre-service teachers in order to improve the validity and reliability of the interview question and the data gathered in the interviews. Guided by the answers of the pre-service teachers, the interview protocol was enriched with additional questions. After these revisions, the interview protocol was examined one more time by a chemistry educator for further revisions. The interviews were conducted with 11 out of 14 pre-service teachers in the study. The pilot study was conducted with two of the pre-service teachers, as stated above and

another pre-service teacher did not want to be interviewed. The interviews took approximately 20-25 minutes and were audio-recorded.

The Process

The study lasted for 11 weeks, including the data collection process. The study proceeded through four main steps as described below:

1. *First Week:* The achievement test was administered to the pre-service teachers as a preliminary test at the beginning of the semester. The pre-service teachers were given 50 minutes to answer the test questions.
2. *Second Week:* A lesson plan was prepared by the researchers in order to train the pre-service teachers on writing reflective journals. The training session took 90 minutes.
3. *Third Week – Tenth Week:* During the period between the third week and the tenth week, experiments regarding different subjects were performed in one-hour periods; after these experiments, the pre-service teachers were asked to write reflective journals with a half-hour time limitation.
4. *Eleventh Week:* The pre-service teachers were given the achievement test as a post-test. The pre-service teachers were given 50 minutes to answer the open-ended questions.
5. *Twelfth Week:* An interview was conducted with the pre-service teachers to examine their views regarding the effects of keeping reflective journals.

Data Analysis

The data gathered from the reflective journals and interviews were analysed inductively by employing a content analysis approach. Content analysis involves summarizing and reporting the content of a speech or text (Cohen, Manion, & Morrison, 2007). The aim of content analysis is to determine the concepts and relationships that can explain the data gathered (Yıldırım & Şimşek, 2011).

First, a coding scheme was determined by reading the reflective journals four times. An instructor who was working on qualitative analysis and carrying out his postgraduate studies in education also coded the data independently. Afterward, mutual codes were determined by the researchers through discussion. Each journal was then analysed according to these codes. Forty reflective journals, five from each pre-service teacher, were coded separately by both researchers, who then compared their codes after each coding session. They came to an agreement by discussing their decisions when they encountered differences in the codes they assigned. Over the eight-week period, the consistency between the codes determined by two different researchers was 89%. Since the inter-rater agreement was greater than 0,70, the coding phase of the analysis was considered as quite reliable (Miles &Huberman, 1994).

Analysis of the data gathered during the interviews was initiated by transcribing the audio records verbatim. Afterward, the transcripts were read by the researchers, who made notes, comments and queries in the margins of the transcripts (Merriam, 2013). In this manner, the data gathered via the interviews were coded. Later, these codes were classified and themes were generated (Yıldırım & Şimşek, 2011). These themes were then examined by a chemistry educator as an external observer, and the researcher and the observer finalized the themes through discussion. Afterward, the codes and themes were organised, the data were tabulated, and the findings were defined and interpreted (Johnson & Christensen, 2014).

The achievement test consisted of 16 questions, and the highest score that can be earned is 48. In order to grade the responses to the achievement test, a rubric was developed by a chemistry education faculty member who specializes in data analysis. The pre-service teachers' answers for each question were sorted in one of the following categories: "exactly correct", "partly correct", "false" and "no sense/blank". The explanations of these categories can be seen in Table 2.

Categories	Mark	Explanation
Exactly correct	3 points	Includes all the components of the expected answer.
Partly correct	2 points	Includes some of the components of the expected answer.
False	1 point	Includes false information regarding the expected answer.
No sense/blank	0 point	An irrelevant answer is given; blank, or the question is repeated without a change.

Table 2: Achievement test rubric

The achievement test of 10 of the pre-service teachers was graded by two researchers together. One of the researchers was a doctoral candidate at the time of the analysis, and the other had a doctoral degree in chemistry education. They utilized the above mentioned rubric in order to analyse the achievement test. The consistency between the graders was determined as 90%, which is quite high.

In determining whether there was a meaningful difference between the pre-service teachers' pre- and post-test scores, the Wilcoxon Signed Rank Test, a non-parametric statistical calculation, was utilized, since there were fewer than 15 pre-service teachers under examination (Büyüköztürk, 2009).

Findings

In this section, the findings gathered from the pre-service teachers' reflective journals, achievement test responses and interviews are presented respectively and separately.

Findings from the Reflective Journals

A total 105 journals were kept by the pre-service teachers. Analysis of these journal entries was carried out according to five themes, including class process, long-term effects, emotion/attitude, self-evaluation and experiment-oriented learning. In Table 3, each theme, the codes gathered under each theme and the frequency of the codes in the journals are presented. Following this, illustrative quotes from the reflective journals are provided.

Class Process

The class process theme involves factors and events affecting learning in the laboratory, either directly or indirectly. There were six main repeated codes under the class process theme: preliminary preparation, experiment-oriented opinion, efficacy of the teaching method, reflective journal, and instructor's attitude. The frequencies of these codes are

outlined in Table 2. Each code gathered under this theme is explained, and short quotes from the pre-service teachers' reflective journals are presented.

Preliminary Preparation: The most frequently repeated code in the journals was preliminary preparation (f=61). The pre-service teachers generally described what kind of preparation they did for the laboratory and how this preparation affected their learning.

Experiment Oriented Opinion: As seen in Table 2, the second most frequent code in the journals related to the class process is related to the difficulty or ease of the experiments. A total of 31 journal entries addressed and argued the degree of difficulty of the experiments.

Efficacy of the Teaching Method: Another code mentioned in the pre-service teachers' journals pertains to the efficacy of the teaching method used in the laboratory. The pre-service teachers generally expressed positive opinions about the effects of experimentation and group work in the laboratory lessons on their learning (f=28).

Reflective Journal: Another code presented under the class process theme is related to the use of reflective journals (f=22), where in the pre-service teachers mentioned their positive or negative opinions about the reflective journals they keep throughout the semester.

Attitude of the Teacher: In a few of the journals (f=8), the pre-service teachers expressed their views about their teachers' attitudes during the laboratory sessions.

Themes	Codes	f	Quotes from the journals
Class Process	Preliminary preparation	61	…when performing the experiment, being prepared for the lesson is as important as skill, courage and knowledge. When starting the experiment, the teacher first checks whether we have preliminary preparation or not… If I can answer the questions she asks, I feel very motivated by that. (P10)
	Experiment Oriented Opinion	31	There were too many measurements. It was a simple experiment, but it was too easy to make mistakes in numeric expression. (P12)
	Efficacy of the teaching method	28	Since we share our tasks with friends during the experiments, I don't ever get bored performing them; on the contrary, it makes the experiment more engaging. This way, I understand that group work is better for me.(P3)
	Reflective Journal	22	I have benefited from reflective journals a great deal, because while I write, I think about how this week's class helped me. It shows what knowledge I hold. It teaches me to question myself. (P5)
	Teacher's Attitude	8	The most obvious thing that I realized about you is that you care about your students. It is not easy to read all this writings. We feel too lazy to write even one writing in one week. (P6)
Long- term Effects	Awareness/Gain	58	...all the clues are hidden in the teacher's explanation of the experiment. No matter how prepared I come to the experiment or how carefully I listen, the most important thing is to listen to the teacher in the beginning of the lesson.... (P9)
	Plan/expectation/ suggestion	40	…the first thing to do is make a little investigation about how to use the equipment in the experiment… and the last thing is to animate the steps of the experiment in my head just like a movie. If I do these before the lesson, I feel that I can eliminate some doubts of mine on some matters. (P13)
Feeling-Attitude	Positive feeling/attitude	55	Since it is more exciting and memorable when we perform the experiment and see it with our own eyes…that's why I love chemistry laboratory class. (P8)
	Negative feeling/attitude	22	Before going into the laboratory, I had doubts that made me hesitate. The first one of them was, it may sound a little funny, "will I be able to get out of the laboratory without blowing it up?"...(P10)
Self-evaluation	Achievement in experiment/lesson	37	We saw that when we do everything that we are told, we reach our aim with the experiment. (P1)
	Participation in the experiment	10	I like performing experiments; now I perform almost all of the experiments, and my friends help me. (P1)
	Deficiencies/ inadequacies	10	…I used to struggle to understand and solve questions like, "this amount left from that amount, how much of it is a precipitate?" that I came across. (P7)
Experiment Oriented Learning	Gained knowledge	37	I learned that some other solid matters than naphthalene sublime; for instance, iodine. (P5)

Table 3: The content of the reflective journals

(P1) = Participant 1 (Pre-service teacher)

Long-Term Effects

The pre-service teachers' learning, apart from the intended objectives during the classes, and their prospective plans regarding learning in the laboratory were recorded under the theme of long-term effects. There are two main tendencies under this theme: Awareness/Gain; and Future plans, expectations, and suggestions.

Awareness/Gain: As seen in Table 3, in 58 of the journal entries, the pre-service teachers addressed their awareness and gains from the laboratory sessions or in the preparation process.

Plan/Expectation/Suggestion: The pre-service teachers frequently mentioned that they planned for the experiments ahead of time or for the future (f=40); and that they had expectations or made suggestions for themselves. Sometimes, they went beyond what they learned in the laboratory sessions and reflected on their personal development.

Feelings/Attitude

The Feelings/Attitude theme consists of statements expressing the pre-service teachers' feelings during class or their attitudes about the class. As seen in Table 3, there are two repeating codes under the Feelings/Attitude theme: Positive Feelings/Attitude (f=55) and Negative Feelings/Attitude (f=22).

Positive Feelings/Attitude: The third most frequent code is positive emotion/attitude, in which the pre-service teachers expressed positive emotions or attitudes towards the lessons.

Negative Feelings/Attitude: In almost one fifth of the journal entries, the pre-service teachers mentioned negative emotions and attitudes towards the course.

Self-Evaluation

Under the Self-evaluation theme, the pre-service teachers commented on their own knowledge, achievement and performance. There are three repeating codes under this theme: achievement in lessons/experiments, participation in the experiment and missing subjects. The repetition frequencies of these codes are given in Table 3.

Achievement in lesson/Experiment: The pre-service teachers frequently wrote notes about whether they were successful or not at the end of an experiment (f=37).

Participation in the experiment: From time to time, the pre-service teachers mentioned their level of performance during an experiment (f=10).

Deficiencies/Inadequacies: Occasionally, the pre-service teachers expressed the issues by which they felt challenged concerning the subject of the experiment (f=10).

Experiment Oriented Learning

The theme Experiment-oriented learning consists of the knowledge that formed the topic of the experiment and the information the pre-service teachers learned from the experiment. The only code repeated in this theme is Knowledge gained.

Knowledge gained: Occasionally, the pre-service teachers wrote about the knowledge they gained during their laboratory experiences (f=37).

Findings from the Achievement Test

The findings from the achievement tests that were applied to the participants as a pre- and post-test are presented here. The minimum score that could be earned on the test was 0, and the maximum score was 48. As can be seen in Table 4, the pre-test mean score was 15.1, and the post-test mean was 24.6.

Descriptive Statistics			
Test	N	Mean	SD
Preliminary	14	15.1	4.1
Post	14	24.6	2.1

Table 4: Findings regarding the descriptive statistics of pre-service teachers' pre- and post-test scores

The achievement test scores for the pre- and post-treatment were compared via the Wilcoxon Paired Comparison Test. As can be seen in Table 5, there was a meaningful difference between the pre- and post-test scores in favour of the post-test scores (z=-3,31; p<0,05).

Groups	N	Mean Rank	Rank Sum	Z	P
Negative Rank	0	0.0	0.0	-3.31*	0.000
Positive Rank	14	7.5	105.0		
Equal	0				

Table 5:The Wilcoxon Paired Comparison Test Results

*Based on negative ranks.

Findings from the Interviews

In order to determine the pre-service teachers' views regarding effects of the reflective journals on learning, an interview was conducted with the participants at the end of the course. The pre-service teachers' views are presented in Table 6 in accordance with the interview questions. It can be seen that nine out of eleven pre-service teachers perceived a positive connection between the reflective journals and their chemistry learning. For example, P6 explained her opinion that: *I think it has positive effects on learning, because we see what we learn or what we couldn't learn. I sometimes looked at them (the feedback) and examined what were your (the teachers') opinions and thoughts about them.*

On the other hand, one pre-service teacher claimed that keeping reflective journals had no effect on her learning. *In reflective journals we were just telling about our mood in the class and what we did in that lesson. That is why I think that I did not gain any benefit from it for my learning (P8*).

Themes	Codes	Pre-service teachers	F
Effects of reflective journals on learning	Positive Effect	P2,P3,P5,P6,P9-P12,P14	9
	No Effect	P8	1
	Undecided	P7	1

Table 6: The pre-service teachers' views about the relationship between reflective journals and learning

Another salient finding derived from the interviews was that the pre-service teachers felt challenged in terms of expressing their views about the relationship between reflective journals and their learning. For instance, when P2, P3, and P7 were asked about their views, they stated that they did not have any specific idea. As P7 explained, *…we got bored while we were keeping reflective journals. I think... that is why we cannot write what we think, we had time issues. But, I do not know... there may be... (a positive effect on learning), but I do not have a specific idea.* However, in the subsequent parts of the interviews, P2 and P3 expressed more insightful views regarding the positive effect of reflective journals on their learning.

As shown in Table 6, nine of the pre-service teachers thought that the reflective journals had positive effects on their learning. When these participants' views were further examined in the interviews, three major themes emerged regarding the effectiveness of the reflective journals, as illustrated in Table 7.

Themes	Codes	Pre-service Teachers	F
Meta-cognitive Awareness	Realizing what is learnt or not	P2, P3, P5, P6, P11	5
	Realizing how to learn	P9, P14	2
	Deciding what to do next	P5	1
Feelings	Reducing anxiety/Developing self-confidence	P9, P11, P12, P14	4
Motivation	Motivation increase out of class	P2, P3, P10	3
	Motivation increase in class	P2, P5, P14	3

Table 7: Pre-service teachers' views on reflective journals' effects on their learning

As illustrated in Table 7, the pre-service teachers' views on the matter were categorized according to the themes of meta-cognitive awareness, feelings, and motivation. For instance, they evidenced three different views under meta-cognitive awareness. The first, "realizing what is learnt or not" was observed in five of the pre-service teachers' interviews (P2, P3, P5, P6, P11). These participants pointed out that they realized what they had learned and what kind of deficiencies they had. For instance, P3 expressed that*…everything is gathered in our heads when we write the journals; we write there what we learnt and what we hadn't learned. We understood what we learnt and didn't learn at the last minute.*

On the other hand, P9 and P14 presented different views by expressing that the journals helped them "understand how they learn:"

…you can think [about] how you learned while writing reflective journals; for instance, by means of the journals, I realized that you cannot learn anything by watching the experiment from a distance. I think that reflective journals made me realize that [I need to] pay attention at all times, learn more and study more. (P9)

P5 stated that the reflective journals had helped her "make decisions." She expressed that, while writing the journal entries, she realized that she had not asked for her teacher's

assistance with the subjects that she did not understand. As soon as she realized this in the course of writing her journal entries, she decided to ask questions about the subjects with which she struggled.

Under the Feelings theme, a few of the pre-service teachers (P9, P11, P12, and P14) stated that when performing experiments in the laboratory, they were concerned and felt clumsy about the subject, but by writing reflective journals, they were able to eliminate their concerns and increase their level of self-confidence:

I recognized that my fear about the laboratory declined overtime. I think that keeping reflective journals and receiving feedback from you [the teaching assistant] provided this improvement (P9).

Under the Motivation theme, three of the pre-service teachers (P2, P3 and P10) stated that keeping reflective journals motivated them to study more. P2 noted that she could not find anything to write in her journal when she did not study; thus, the journal writing urged her to study. The following quote from P10's interview demonstrates this view, as well:

…in order to write, you need to get some information beforehand; you come prepared, which is nice for you to learn about the experiment. You say to yourself, 'I am going to write something in the journal, so I need to know something to write about the experiments.' Because of this, I started preparing for the experiments.

A few of the pre-service teachers (P2, P5 and P14) also reported that writing the reflective journals increased their attention and participation in the class, constituting a positive effect on their motivation. For example, P14 expressed her ideas during the interview as: "(thanks to reflective journals) I feel more connected to the experiments."

Discussion and Conclusions

The discussion and conclusion section of the study is presented under two sub-headings in order to address the purposes of the study; the efficacy of the reflective journals and the effects of the reflective journals on pre-service teachers' achievement.

Efficacy of Reflective Journals

When the data from the interviews is examined, it can be seen that most of the pre-service teachers felt that writing reflective journals had a positive effect on their meta-cognitive awareness, feelings, and motivation (see Table 5). Based on these findings, we can conclude that keeping a reflective journal in the GCL1 class had a positive, but indirect effect on the pre-service teachers' learning. The participants reported that while searching for answers for the prompts provided for them, they thought about their learning; thus, they gained greater understanding about what they had learnt and how they learnt. Hereby, they improved their meta-cognitive awareness (Ersözlü & Arslan, 2009; Fernsten & Fernsten, 2005; Kim, 2005; Mair, 2010). The fact that some of the pre-service teachers' statements revealed that keeping reflective journals helped them to understand "what they have learnt," to recognize "how they learnt it" and/or to "make decisions" (see Table 5) demonstrates that the category of meta-cognitive awareness is different for each pre-service teacher. Their individual differences may have been the reason for the differentiation in the changes in their meta-cognition, even though they were taught in the same class (Feyzioğlu & Ergin, 2012; Yürük, 2005). It is believed that guiding questions for keeping a journal, such as "what did you learn?" and "what do you need to learn?" are very useful for encouraging pre-service teachers to organise and clarify what they learn while keeping their reflective journals.

Moreover, the participants' statements that keeping reflective journals increased their motivation in class or out of class may indicate that they took more responsibility for their learning (Wilson & Jan, 1993). The findings from the interviews also support this claim, as many indicated that writing duties for the reflective journals motivated them to study more (Lee, 2013). Analysis of the pre-service teachers' reflective journals also revealed that they had observed and questioned themselves, as well as their teachers, during the class. This led them to gain awareness about learning chemistry,as well as implementing plans and identifying certain strategies for learning chemistry (Langer, 2002).

The fact that three pre-service teachers stated in the interviews that keeping reflective journals helped them eliminate their concerns and gain more self-confidence maybe a result of facing their own concerns or sharing them with someone else (i.e., their teacher). For example, some of the feedback provided by the teaching assistant including "don't hesitate to use the laboratory equipment" or "if you are actively involved in performing the experiments, you will recognize the equipment easily, and you can eliminate your uneasiness about using the equipment" may have played a role in pre-service teachers' gaining self-confidence. This and other similar feedback may have also encouraged some of the pre-service teachers to participate in the laboratory activities. The participants' journal entries also supported this claim, as their retrospective reflections regarding the course highlighted the change in their efficacy and participation in the laboratory activities. This conclusion is unique in terms of using reflective journals in a chemistry laboratory, as opposed to keeping reflective journals in social subjects.

The Effect of Reflective Journals on Pre-Service Teachers' Achievement

The purpose of this study was to evaluate the effectiveness of feedback-supported reflective journal-keeping activities on first-year pre-service teachers' achievement. The fact that there was a significant difference between the pre-service teachers' pre- and post-course achievement test scores indicates that keeping a reflective journal after performing experiments in a GCL1 class had a positive effect on achievement. Similar results were reported from researchers in other fields (Keskinkılıç, 2010; Kırnık 2010; Şahin, 2010). For instance, Kim's (2005) study showed that an on-line reflective learning tool was very effective for students' problem solving performance in both agricultural business management and statistics courses. Lin and Liu (2012) supported this claim with respect to a robotics course, while similar results were reported by Burrows, McNeill, Hubele and Bellamy (2001) for engineering subjects. This indicates that keeping a reflective journal is very effective in terms of achievement for a wide range of domains and subjects; the current study strengthens these findings by providing evidence from a different domain.

However, although there was a significant difference between their pre- and post-course achievement test scores, the pre-service teachers' average post-course achievement test scores were around 24.6 out of 48, which is low. This indicates that the effects of keeping reflective journals on achievement may be considered as very low, or mediocre at best.

In addition, as stated in the previous section, one of the pre-service teachers mentioned that keeping reflective journals did not have any effect on her achievement, where as another stated that she did not have a definite opinion about this matter. The reason for this maybe the fact that thinking and writing about learning is not directly related to the knowledge acquisition process. While it is expected that by keeping reflective journals, pre-service teachers' meta-cognitive learning strategies such as planning, controlling, and managing may be developed, thus increasing their success (Taşçı, Altun, &Soran, 2008), this relationship may not be apparent for some pre-service teachers.

Furthermore, it was determined in this study that the learners reflected on the teaching methods and techniques in the class, but they rarely reflected on their own learning process or their personal studying strategies. The reason for this maybe that learners do not benefit from different strategies when studying, or that they do not study enough for the class. Another reason for this result maybe that the prompt question "what did you learn about your learning in this lesson, and how did you learn it?" was not clear enough. Thus, different guiding questions maybe posed for reflection in order to encourage individuals to think about their own learning and studying strategies.

The fact that the pre-service teachers frequently mentioned their preparation for the experiments, their lesson oriented awareness and their positive emotions in their journals leads to the conclusion that they preferred to reflect on the positive aspects of their experiences in their journals. As a matter of fact, only about10% of the journal entries mentioned any deficiencies that the participants had determined about themselves. The reason for this may be that they knew the researcher was going to read the journals (Boud, 2001). Another reason might be their inability to evaluate themselves effectively enough to decide what they knew and did not know. This may also be the cause of the inadequate achievement test scores; as the participants did not discern their own deficiencies and shortfalls, as well as their studying strategies, they may have maintained superficial level of understanding of the concepts, leading to low performance levels on the achievement test regardless of a small gain between the pre- and post-course administrations. In this sense, the researchers were led to conclude that the pre-service teachers' meta-cognitive awareness level was not high. It is considered that individuals who know their strengths and weaknesses and who are informed about the learning process learn more easily, and learning is more profound and permanent (Eaton, 1985). Therefore, it is believed that the reason for the pre-service teachers' low GCL1 achievement is that they did not possess the aforementioned skills at an adequate level. On the other hand, the majority of what is learnt is directly related to working memory; thus the capacity and functioning of working memory affect the rate and extent of learning. In other words, meaningful learning and achievement rely on the functioning of working memory, regardless of domains or subjects (Fenesi, Sana, Kim, & Shore, 2014). Therefore, the effectiveness of the journal-keeping activity may be influenced by working memory limitations. However, working memory limitations and cognitive load theory were not examined in this study, which could be an important limitation in terms of generalizing our findings about learning and achievement.

Furthermore, this study was the first time the participants had encountered reflective journals-keeping, and in addition, this portion of the study lasted only eight weeks. This period of time may not have been sufficient for the participants to become accustomed to reflective writing and to develop an automatized process, which would be referred to professionalization (Chalk & Hardbattle, 2007). High quality journal entries dealing with deeper reflections maybe prepared after a longer period of time and experience. Under this circumstance, the effectiveness of journal-keeping activities on academic success might be examined more clearly.

Suggestions and Implications for Teaching

Based on the results gained from this study, some suggestions regarding this study, as well as further studies, are presented below:

- It is believed that asking learners with limited experiences in laboratories to keep reflective journals can enable learners to adapt to a chemistry laboratory easily. Providing timely and guiding feedback to learners by reading the reflective journals would be necessary to this process.
- It is considered that performing a reflective journal writing activity with different grade levels may be effective on learners' reflective thinking skills and conceptual development. It is also thought that starting the activity in lower grades would provide learners with a better comprehension of the approach.
- It is determined that the pre-service teachers' gains in terms of achievement from the treatment were below expectations and relatively low. This reminds us that the teaching process maybe enriched through different methods in order to elicit better performance from pre-service teachers. Accordingly, it is believed that apart from reflective journals, using different approaches (asking questions, keeping portfolios, performing self-evaluations, and other similar activities) to improve reflective thinking might affect learners' achievements, as well.

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Appendix 1

Prompt Questions

1. What did you learn about your learning in this lesson, and how did you learn it?
2. Before conducting the experiment, what did you do to get ready for it?
3. What did you learn about the experiment?
4. How did you learn it?
5. How can you improve your learning?
6. What was easy/difficult about the experiment?
7. Why did you find it easy/difficult?

8. What do you think that you need to learn?
9. What should you do to learn it?
10. Do you think that you have achieved the objectives of the course?
11. What did you feel during the learning process?
12. Why did you feel this way?
13. What do you think about the lesson and your personal performance (before the lesson, during the lesson and after the lesson?)
14. What did this class allow you to decide to start doing?
15. What did this class allow you to decide to stop doing?
16. What did this class allow you to decide to continue doing?
17. What would you have learned in this lesson?

Appendix2

Achievement Test

1. **a)** Please explain the difference between heat and temperature concepts.
b) 60 g water is heated to a certain temperature in a beaker. In another beaker, there is 100 g of water at room temperature (20°C). When water in these two beakers is mixed, the final temperature of mixed water is 50°C. Please calculate the initial temperature of the water in the first beaker.

2. **a)** How do you know if a solid substance is pure or not? Please explain.
b) Explain the difference between crystallization and precipitation.
c) What are the characteristics of a solvent to be used in purification by crystallization? Please explain.

3. 0.45g of naphthalene are placed in a porcelain capsule for purification. The mass of an empty watch-glass is weighed at 37.90g. Filter paper is weighed 0.98g before the experiment. After perforating the filter paper with a needle, it is placed over the porcelain capsule and it is closed above with the watch-glass. The porcelain capsule is heated slowly over a Bunsen burner, and the watch-glass is continuously cooled from the outside with the aid of ice and a damp cloth. The mass of the watch-glass after the experiment is 38.10g, the filter paper was weighed at 1.02 g. Based on these data, please calculate the percentage of pure naphthalene in the bulk sample.

4. When a platinum wire is immersed in a solution of Na^{+} in acidic medium and exposed to flames, an intense yellow colour is observed. When the same wire is cleaned and immersed in a solution of Ca^{+2} in acidic medium and exposed to flames, a brick-red colour is observed. So,

a) What happens to Ca^{+2} in this process? Please justify your answer with the associated chemical equation.
b) Why do you think that solutions with different ions show different colours in a flame?

5. 3 ml 0.1 M $Pb(NO_3)_2$ and 12 ml 0.1 M K_2CrO_4 solutions are mixed for a precipitation reaction. Please calculate the amount of the precipitated amount of $PbCr_4$ in grams and the concentration of the remaining ions in the solution. ($PbCrO_4$: 323g/mole)

6. **a)** Please give examples of acidic, basic and neutral salts and show the neutralization reactions of these salts.
b) Please list the properties of acids and bases. (Write at least three items for each)

7. The mass of an empty evaporation container is 55g. When 25ml NaCl solution put into this container, their total mass measured as 80.6g.When the water is completely evaporated from the container, the mass of the container is 55.8g. Based on these data, please calculate:

a) Concentration of the initial solution;

b) Percentage by mass of the solution;

c) Amount in grams of salt in 100ml water.

8. **a)** By using density of 1.15g/ml and %80 by mass CH_3COOH solution, how 0.1M 100 ml CH_3COOH solution is prepared from using stock solution? Please explain it making the necessary calculations. (CH_3COOH: 60g/mole)

b) How can 0.04 N 100 ml $KMnO_4$solution be prepared? Please provide the necessary calculation and explain the process of solution preparation. ($KMnO_4$: 158g/mol)