How can Pre-Service Science Teachers Reflect their Critical Thinking Skills in their Writings?

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Abstract

In this research, pre-service science teachers' writings written in a biology laboratory course were examined and the development of writings skills was monitored from the critical thinking skills perspective. In this context, the preservice teachers were asked to design and build a fully enclosed ecosystem model (bottle ecosystem), collect data from these ecosystems, and report on all processes. The observational case study design was used in this research and research was carried out with fifty-two preservice science teachers from a public university in Turkey. To determine the development of preservice science teachers' writing skills, unstructured focus group interviews and document review methods were used for data collection. The content analysis method was used for the analysis of the data. According to analyses, pre-service science teachers had difficulties in reflecting their critical thinking in their writings, but it was determined that they were able to improve themselves in the process. According to the research, if an appropriate learning environment is provided, preservice teachers can reflect their critical thinking in their writings, and this can improve their science literacy.

Introduction

Scientific literacy enables students to master scientific ways of accessing knowledge, understand and participate in scientific discussions, learn science concepts, and criticize scientific findings (Pearson et al., 2010). Scientific literacy also includes the ability to express findings, results, and assumptions in writing. Writing skill is a critical tool for scientific research (Yore & Treagust, 2006) and is often seen by some researchers (Klentschy & Molina-De La Torre, 2004) as a tool for encouraging learning in science. Writing skill requires a well-organized systematic thinking skill (Gonye et al., 2012; Hasani, 2016), and it is not only a part of the scientific method but also a way of communicating mental processes (Yore & Treagust 2006). Moreover, there is a close relationship between writing skills and creativity, as it allows students to reflect on their ideas (Eymur, 2018; Haerazi et al., 2020). Despite the close relationship between writing skills and science literacy, the writing experience of pre-service science teachers is limited and this situation negatively affects the development of critical thinking and scientific literacy (Cremin & Oliver, 2017). In this research, the reports written by the pre-service science teachers in an application

carried out within the scope of the biology laboratory applications course were examined and the development of writings skills was monitored from the critical thinking skills perspective.

Background of the Study

There is extensive research in the literature examining the writing experiences and perceptions of pre-service teachers (Aydın, 2019; Daisey, 2009; Draper et al., 2000; Dumlao & Pinatacan, 2019; McCarthey et al., 2014; Miatin & Wiedarti, 2019; Nasihah & Cahyono, 2017; Norman & Spencer, 2005; Woodard, 2013, 2015). Studies show that the majority of preservice teachers consider themselves insufficient to write before they take any education on writing or scientific writing (Daisey, 2009). One of the main reasons for this situation is that the preservice teachers do not have much information about writing experiences (Draper et al., 2000), and they generally perceive the writing experiences as personal writings and academic writings. Norman and Spencer (2005) found that the majority of prospective teachers (63%) preferred personal-creative writing styles, and a small number (13%) preferred analytical or academic writing.

Aydın (2019), in his research conducted with Turkish teacher candidates studying in the field of language teaching, showed that pre-service teachers' perceptions of writing self-efficacy increased during their education. This situation reveals meaningful results that the writing skills of teacher candidates can be improved through effective practices. Contrary to this finding, Miatin and Wiedarti (2019) reported that although students improved their writing self-efficacy, they could still underestimate their writing skills. At this point, it is revealed that teacher candidates' writing motivation is as important as writing self-efficacy. There is a positive and significant relationship between students' writing skills and their motivation to write (Nasihah & Cahyono, 2017). Cremin and Oliver (2017) analyzed the writing skills of teachers and they found that pre-service teachers in the USA have low motivation and self-confidence in writing. Therefore, it is important to develop the writing motivation of the pre-service teachers along with their writing skills.

Pytash (2013) states that pre-service teachers should be exposed to teaching approaches that support the development of writing skills to gain students' writing skills. Argumentation can be an effective tool to improve pre-service teachers' writing experience. According to Preiss et al. (2013), argumentative writing is an important type of writing that should be learned at school and university and it is stated that students' argumentative writing skills are supported by their critical thinking skills (Hasani, 2016). Erenler and Çetin (2019) examined the effect of argument-based inquiry (ADI) on pre-service science teachers' scientific writing skills and determined that ADI could help pre-service science teachers improve their scientific writing skills. Similarly, Çiğdemoğlu et al. (2017) analyzed the effect of argumentation practices on pre-service science teachers' chemistry literacy and reported that some pre-service science teachers had difficulty in identifying scientific problems and refuting their claims while writing their reports. They also noted that they observed fewer claims, judgments, and proofs in the reports. As justification, they stressed that trainees often write lab reports such as cookbooks, as they have limited experience in supporting their claims and providing evidence.

Purpose of the Study

Studies have emphasized that undergraduate students need more explicit instructional support for self-regulation to overcome the difficulties they face when they have to write argumentative texts (Ferretti & Lewis, 2013). Within the scope of this research, pre-service science teachers'

reports written in the biology laboratory were examined and the development of writings skills was monitored from the critical thinking skills perspective. Research questions are as follows; (RQ 1.) How can pre-service science teachers reflect their critical thinking skills in their writings? And (RQ 2.) how would a classroom practice integrated into the biology laboratory course affect pre-service science teachers' writing skills? Findings from this study can provide concrete clues on how pre-service science teachers can reflect their critical thinking in their writings and contribute to the literature to support pre-service science teachers' scientific literacy.

Method

The observational case study design (Bogdan & Biklen, 2007) was used in this research. A case study is a methodology, in which a wide variety of data collection tools (Yıldırım & Şimşek, 2005), such as focus group interviews, observations, and documents are used to analyze one or several situations in an integrated manner within the boundaries of environment and time (Benz et al., 2008). In observational case studies, participant observation is used as a primary data collection tool and the environment examined is usually schools or rehabilitation centers. According to Benz et al. (2008), case studies carry more validity potential than other qualitative research methods that are inherent because case studies usually involve triangulation as a data collection method. However, triangulation was not undertaken in this research. Considering the primary goal of the study, which was to determine and develop the writing levels of pre-service teachers, documentation was used as the primary data collection method, and unstructured interviews to confirm the analysis of documentation. The lack of triangulation in the data collection method can be considered a limitation regarding the validity of the research. On the other hand, the positive contribution of the number of participants to validity should not be overlooked. Research findings were based on a large number of data that increased the trustworthiness, generalization, and transferability of the research. Besides, to enhance the reliability of the qualitative analysis, two field specialists (with the author, a total of three coders) were asked to encode a randomly selected data set, and the inter-coder agreement was found to be 84%. (MacPhail et al., 2016).

Participation and Context

The current research was carried out with pre-service science teachers from a public university in Turkey, and implementation was performed within the scope of the biology laboratory course. Implementation and data collection processes were done in the spring semester of the 2017-2018 academic year and lasted six weeks in total during which the ecosystem topic was taught. Fifty-two undergraduate students (34 female, and 18 male) that were also enrolled in the General Biology 2 course in the same academic year participated in the research. Therefore, participants were assumed to have basic knowledge and skills related to ecosystems, such as energy flow in habitats. Since the university in which this research was conducted is a public university and students are eligible to universities according to their level of success in the national examination in Turkey, it is considered that all the participants had a similar academic background. Besides, the socio-economic levels and genders of the participants were not studied as a variable in the study. Before the research, the process was explained to the pre-service teachers, and it was stated that the implementation would not influence their grades in the biology laboratory course. The implementation and data collection processes were carried out by the author. Table 1 summarizes all the practices and data collection processes carried out within the scope of the research.

Biology laboratory I and II courses are compulsory courses that cover cells, tissues, and systems. This study was carried out in a six-week-long part of biology laboratory course II on the topic of the ecosystem. In this context, the preservice teachers were asked to form groups of four (13 groups in total) to design and build a fully enclosed ecosystem model (bottle ecosystem) consisting of water and land ecosystems that could sustain for two weeks without any external intervention, collect data from these ecosystems and report on all processes. Bottle ecosystem applications, it is aimed to examine the factors that affect ecosystems (Brown et al., 2008). First, it is necessary to determine the factors to be tested (dependent and independent variables) and prepare an appropriate ecosystem design. The prepared ecosystems are composed of two components; aquatic and terrestrial. In the terrestrial ecosystem, a land plant and a small-sized land animal must live together, and the nitrogen, oxygen, and water cycle must be well designed to maintain the ecosystem. The water source of the land ecosystem is an aquatic ecosystem at the bottom. Similarly, an aquatic ecosystem should be designed in such a way that a water plant and a small water animal can live together. Once the ecosystems are completed, they are closed off to prevent any external intervention, and therefore all living and non-living elements should contribute to the self-maintenance of the system. The most important problem encountered in this process is the need for nutrients and oxygen. At the beginning of the study, it was explained to the preservice teachers that the bottle ecosystem they created within the scope of the course should sustain itself for two weeks and this should be taken into consideration in the design process. Examples of ecosystem designs, generated ecosystems, and prepared reports are presented in appendices.

Table 1: *Implementation, introduction, and data collection processes*

	Process	*Purpose*	*Data Collection*	*Instructions about Writing*
Week 1	Introduction	Preservice science teachers were informed about the research to be conducted within the scope of this course. Working groups were constructed.	-	The researcher lectured on the report writing approach and how experiments should be reported in this application process.
Week 2	Designing ecosystem models	Preservice science teachers were required to design a closed ecosystem of land and water habitats and report their designs together with their justifications.	**Unstructured interview:** Interviews were held with the student groups to discuss their designs and predictions. **Document review:** The document review method was carried out, and codes extracted from student designs were analyzed.	-

Week 3	Creating eco-systems	Preservice science teachers were required to create ecosystem models in parallel with their designs and update their designs where necessary.	-	Design reports of pre-service science teachers were examined. In this process, the report samples were reflected on the board and the strengths and weaknesses of the statements in the reports were discussed. Critical thinking skills were associated with the expressions included in the sample reports.
Week 4	Reporting the results of the first week of ecosystems	At this stage, the students were asked to observe the changes in their closed ecosystems over a week, report on the reasons for these changes, and compare their expectations and observations. The most basic outcome of this phase is for the students to critique their designs in terms of unexpected events that occur in ecosystems (living deaths, mold-fungal growth, extreme dampness, etc.). All observations were qualitative and the reports contained observation-focused conclusions.	**Document review:** The reports of the groups on their observations and criticisms of unexpected occurrences in their ecosystems were examined and critical processes were coded.	-
Week 5	Opening of ecosystems, making qualitative and quantitative observations, determining the changes in ecosystems.	The ecosystems of the student groups were opened to analyze quantitative observations and measurements of land and water habitats.	-	Examining the reports of pre-service science teachers was repeated. In this process, the report samples were reflected on the board and the strengths and weaknesses of the statements in the reports were discussed. Critical thinking skills were associated with the expressions included in the sample reports.

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Week 6	Reporting the results of the end-of-process ecosystem survey	Preservice teachers were asked to report similarities and differences between the results of their design and the measurements and critique their design.	**Document review:** The final reports containing quantitative observations and measurements of the student groups and their critiques on their design were examined and coded. **Unstructured interview:** In these interviews, the students discussed the state of their ecosystems concerning their designs and models. The participants' attitudes to writing in their final reports were discussed.	-

The application and data collection process are shown in Figure 1.
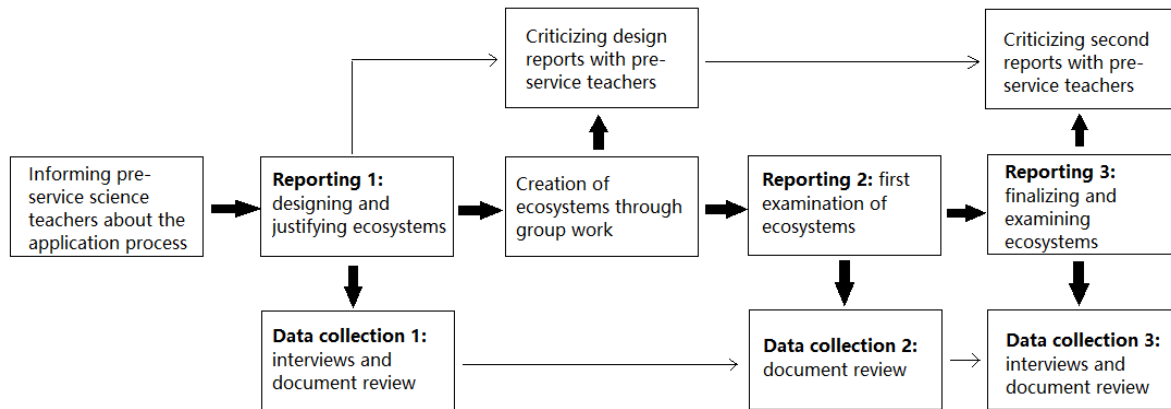
Figure 1: *Implementation and data collection process*

In the implementation process, firstly, the pre-service science teachers were informed about the issues that should be considered when writing a report in the course biology laboratory and how the reports should be in this application process. They were then asked to design bottle ecosystems and report their designs. In this process, firstly the pre-service science teachers' reports were collected and analyzed with the content analysis method. In light of the codes obtained in this process, unstructured interviews were conducted with preservice teachers. The main purpose of these interviews was to determine whether the writing skills determined in the initial reports of the pre-service science teachers were due to a lack of critical thinking skills or a lack of writing

skills. To be able to criticize the situation of pre-service science teachers by reflecting on their critical thinking skills in their reports, the random sample reports were reflected on the board, and the strengths and weaknesses of the statements in the reports were discussed. Expressions in the sample reports and critical thinking skills were associated. Then, pre-service science teachers formed the ecosystems they designed and followed for two weeks. In the meantime, they prepared an interim report and a final report. Since they could not intervene in their ecosystems while writing their interim reports, they only reported their qualitative observations, and unstructured interviews were not conducted while interim reports were analyzed. At this stage, to be able to criticize the situations reflecting the critical thinking skills in their reports, the samples of random reports were reflected on the board, and the strengths and weaknesses of the expressions in the reports were discussed. After this process, prospective teachers opened their ecosystems and made qualitative and quantitative observations, and reported these observations. Immediately after analyzing the final reports, interviews were conducted with prospective teachers. The purpose of these interviews was to determine whether the development of writing skills in the final reports was due to the development of critical thinking skills or the development of writing skills. In these interviews, the preservice teachers' reports were discussed in detail. More detailed explanations of interviews and document reviews are presented in the collection and analysis section.
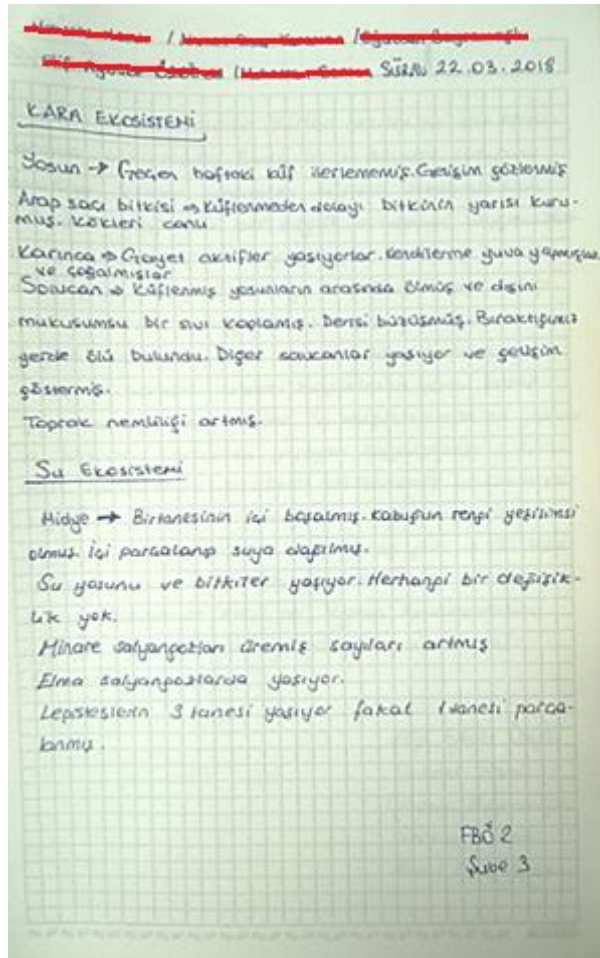
Data Collection and Analysis

In this research, to examine the development of pre-service science teachers' writing skills, unstructured focus group interviews and document review methods were used for data collection.

Unstructured Focus Group Interviews: Two interviews, before and after the implementation, were conducted with the student groups. Interviews undertaken before the implementation were concerned with the ecosystem designs and predictions of the students about their ecosystems, they also aimed to determine their level of critical consideration and reflection abilities on their considerations. At the end of the process (second interviews), unstructured group discussions were held in which the students were asked to critique their designs based on the created models and explain expressions written in their reports. The pre-service science teachers' attitudes toward writing were also discussed concerning their reports. The aim here was to determine whether students reflected their critical thinking skills in their reports. The group interviews lasted approximately 20 minutes, and all the interviews were audio-taped. Question examples asked in interviews are;

> ▶ *How did you think the ants you put in the terrestrial ecosystem would contribute to your ecosystem?*
> ▶ *Do you believe that you could fully express your views in your reports?*
> ▶ *The soil in your design report and the soil you use in your model are different, why did you change it?*
> ▶ *Could you please explain your criticism of the use of chickpea plants in the l ecosystem in your second report?*

Document Reviews: Three different reports concerning design, interim evaluation, and final evaluation processes were collected from the student groups. The first report included pre-service science teachers' designs and justifications. The second report contained observations and critiques of unexpected situations that occurred in the ecosystems created by the groups. The final report

was based on the quantitative observation and measurement results of the groups, the critiques of their ecosystems, and the changes that took place in their ecosystems after two weeks (see examples in appendixes). All these reports were analyzed based on the themes obtained through a literature review and the new codes obtained in the analysis process. Figure 2 shows an example of the final report (report 1);

Transcription

Student names   Date: 22.03.2018

Terrestrial Ecosystem

Moss => Achieved growth. Last week's mold growth didn't increase.

Baby's tears plant => Half of the plants dried out due to moldiness. The roots still live.

Ant => they are very active. They nest and multiplied

Worm => Died in moldy algae; it had covered a mucous liquid. Its skin shriveled. it was found dead where we left off. Other worms have been living and developing.

Soil moisture increased.

Water Ecosystem

Mussel => One of them is empty. The color of his shell was greenish. It's torn apart and scattered in the water.

Seaweed and plants are still alive. Nothing changed.

Minaret snails have reproduced, and populations increased.

Apple snails are also alive.

Three of the guppies are alive, but one of them is torn apart.

Figure 2: *Example of a final report*

The content analysis method was used for the analysis of the data. The primary purpose of content analysis is to "*put together similar data within the framework of certain concepts and themes*" (Yıldırım & Şimşek 2005, p. 227) by organizing them in a way that readers can under-

stand. In the analyzing process, the research on critical thinking was investigated, and the characteristics of individuals who think critically were determined, and these features were recorded as preliminary themes before the study (Bailin et al., 1999, Crow, 1989, Ennis, 1985, Facione 1990, 2000). Specified initial themes are given in Table 2.

Table 2: *Pre-identified Themes and Descriptions Obtained from the Literature*

Themes	Descriptions
Seeking the truth:	This feature refers to education for evaluating alternatives or different thoughts, and contradictory situations. To clarify, this tendency means being able to act objectively even when it is contradicted by internal thoughts and/or reactions.
Open-mindedness:	This can be expressed as being tolerant of different approaches and sensitive to your own mistakes. The primary purpose here is to develop the tendency to judge not only their thoughts but also the opposite views at the same time.
Analyticity:	This refers to the tendency to use reasoning and objective evidence even when faced with potentially problematic situations and difficulties.
Inquisitiveness:	Curiosity or intellectual curiosity refers to the tendency of a person to learn new things without expecting any gain or advantage.
Systematicity:	Refers to the tendency toward organized, planned, and careful research in contrast to a chaotic reasoning behavior; thus, it is possible to use a decision-making strategy that is knowledge-based and follows a specific procedure.
Self-confidence:	This reflects one's confidence in their reasoning processes.
Self-regulation	This can be described as analyzing and evaluating the cognitive activities of a person, the items used in these activities, the results obtained, and in particular, the conclusions obtained through inference by continuous inquiry, verification, and evaluation, and correcting their reasoning and conclusions.

The data collected over five weeks were analyzed simultaneously. Analyses performed during the first three weeks of this process were grouped as initial analyses, while the end-of-process data obtained at the end of the fourth week were grouped under final analyses. The results of the initial and final analyses were compared to determine the efficiency of the prepared course content in enabling the preservice teachers to use critical writing skills.

Results

Within the scope of the research, although the qualitative data obtained from unstructured interviews and reports were collected and analyzed simultaneously, the data obtained from the

reports were prioritized to examine the writing skills of pre-service science teachers. As mentioned above, the main objective of the semi-structured interviews within this research was to determine whether the deficiencies in writing skills identified in the reports are due to defects in critical thinking skills or to the lack of writing skills. For this reason, the findings obtained from the student reports in this section have been tried to be presented with the findings obtained from the interviews. According to the content analysis of the documents, the percentage and frequency values of the obtained themes and codes are given in Table 3. When Table 3 is examined, an increase in the frequency of the pre-service teachers' use of critical thinking skills in their writings during the implementation can be seen. At the beginning of the process (second week), there was no concrete evidence concerning the majority of the student groups' use of critical thinking skills in their writings when examining their ecosystem designs.

Table 2: *The Results of Content Analyses*

Codes	Design Reports		Second Reports		Final Reports	
	f	**%**	**f**	**%**	**f**	**%**
Reasoning	7	25.9	9	25.7	21	27.2
Inference	1	3.7	-	-	2	2.6
Predictions	-		-	-	1	13
Inference-based observations	7	25.9	10	28.6	13	16.8
Quantitative observations	1	3.7	1	2.8	3	3.9
Objective attitude	6	22.2	7	20.0	13	16.8
Critiques of data	-		-	-	-	-
Awareness of one's own mistakes	2	7.4	2	14.3	5	6.5
Lack of prejudice bias	-		-	-	-	-
Evidence-based claims	2	7.4	3	8.5	10	12.9
Using prior knowledge	1	3.7	-	-	6	7.8
Clarification	-	-	-	-	3	3.9

Similarly, unstructured interviews (first week) conducted with preservice teachers, in which they explained and critiqued their ecosystem designs, revealed that their use of academic language did include justifications or reasoning when describing their designs. An excerpt from the unstructured interviews with group 3 is given below (T: teacher, S: student);

T: You used tree moss as a plant in the terrestrial ecosystem you designed.
S1: Yes,
T: Why did you choose tree moss?
S1: It uses photosynthesis and feeds the earthworm.
T: Well, are you sure that the earthworm will feed on the tree moss? Also, do you think that the photosynthesis of tree moss will provide the oxygen-carbon dioxide balance?
S2: It is a really small space. This is why we thought it would be enough. Moisture will form over time, and I think, the tree moss will also grow.
S3: I think the earthworm will not move that much, so the oxygen requirement is not high.
T: What about nutrition?
S2: Well, I think it may eat moss.

This example shows that the preservice teachers implemented their ecosystem designs without deeply criticizing their ideas or conducting sufficient preliminary research, and ignored the threats or possible problems related to the implementation in their design reports. Similarly, an excerpt from the design reports of group 5 is as follows;

We placed the ants in the ecosystem so that they would clean the soil and eat the harmful microorganisms. We used the baby's tears [Helxine soleirolii] because it produces more oxygen and easily finds water with their fibrous roots. Air channels will benefit the equilibration of oxygen-carbon dioxide and the moisture within the water and soil ecosystems.

This quotation shows that the preservice teachers explained the reasons for their choices but refrained from critiquing them. For example, they mentioned that they used ants to clean the land, but they did not clearly state why or how they do this and whether they are suitable for the ecosystem they designed.

It would not be wrong to state that the "reasoning" and "objective attitude" skills are the most outstanding skills of the process because in the reports of preservice teachers and the unstructured interviews, these skills were found intensely at the beginning of the process and they increased about twofold in the process. It would be acceptable to interpret occurrence since preservice teachers often use these skills. Similarly, the skill of "inference-based observations" was one of the most frequently used skills, although not much in the process. At the end of the process, it was determined that preservice teachers used their writing skills more intensively compared to the first two weeks at the beginning of the process, during which time they were asked to examine and report their ecosystems without external links. For example, the following quotation from one of the more recent reports from preservice teachers revealed that they had defined and expressed their own mistakes;

...the water in our ecosystem is more polluted, our fish died and broke apart to pieces, and a very bad smell developed. The cause of breaking apart to pieces of our fish may be due to the decomposers...Because we did not make the right choice of plants, our water was contaminated more quickly, and our fish die (Coded as "awareness of one's own mistakes").

The subject that should be discussed at this point is that the choice of the water plant in this ecosystem design could not be predicted as the right choice at the beginning of the process. This

issue was presented at the last meeting, and they stated that they had made an erroneous preference at the beginning of the process. It can be interpreted as the preservice teachers having an incorrect choice, lacking preliminary knowledge, or having completed their plans without conducting adequate research, and this shows that they did not have a complete critical thinking attitude at the beginning of the process. Also, at the beginning of the process, the same group of students reported these shortcomings, and at the end of the process, their reporting was interpreted as increasing their critical awareness.

As shown in Table 3, there was a significant increase in the preservice teachers' use of preliminary information in parallel with the increase in their sensitivity to their mistakes throughout the process. This is observed in the following excerpt from the fourth week's reports;

> *We saw that some of the plants in our terrestrial ecosystem withered. This is because the soil did not have any air. This hindered the healthy development of the plant, and the structure of the soil may have also affected this situation. (*Coded as Using prior knowledge*)*

In the last unstructured interview with the same group, the preservice teachers were asked why there was previously no expression indicating the use of preliminary knowledge in their design and first observation reports. The following quotation from the last interview reflects the views of the preservice teachers regarding this situation;

> *T: In your last report, you stated that the plant withered because the airless soil prevented the growth of the plant.*
> *S3: Yes, some of the leaves of our plant turned yellowed, and others withered.*
> *T: Did you learn about this in your research during this study?*
> *S1: No, we already knew. We knew this before the research.*
> *T: In your previous reports, we did not find any explanation based on your prior knowledge. What is the reason for this situation?*
> *S3: We have this kind of preliminary information. We learned it in lessons. We used it while creating the ecosystem… But when writing our reports, we didn't talk about it, so we did not know how to write about it.*
> *S2: You did not ask us to write about it.*

As clear from this quote, the preservice teachers were able to use their preliminary knowledge in the design process as a critical thinking skill, but they did not write about how they used this knowledge in their reports. Classroom applications as presented in this paper can help students to become aware of their lack of prior knowledge. However, in this study, there was no concrete evidence indicating an improvement in the preservice teachers' awareness of their lack of prior knowledge.

It was stated in the interviews that the studies on the critique of the reports written in the process contributed to the writing skills of the preservice teachers. However, it should be noted that this development is observed in specific skills defined above. It is possible to say that the main reason for this situation arises from the lack of writing skills of preservice teachers rather than critical thinking skills. To provide evidence of this situation, a quotation from the final reports was shared as follows;
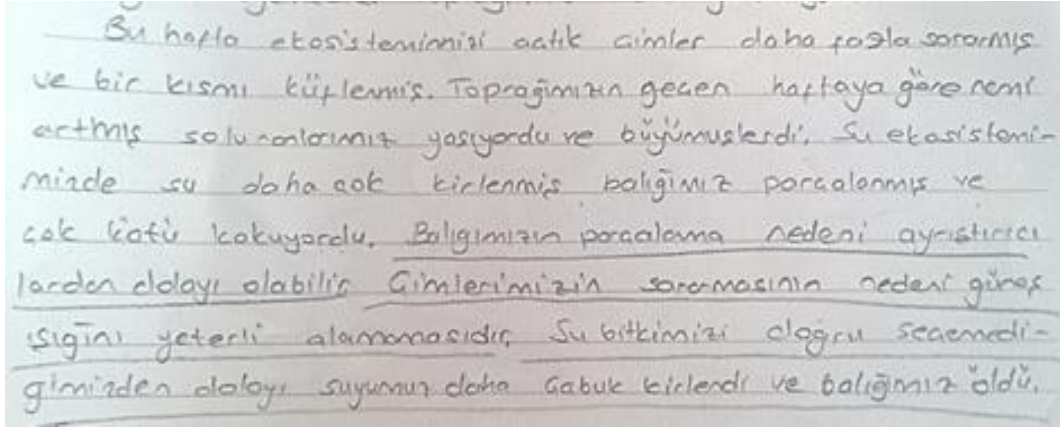
> *This week we opened our ecosystem. The lawns are more sear and some are moldy. Our land had increased moisture compared to last week, and our worms had grown. Water in our water ecosystem was more contaminated, our fish was torn and smelled very bad. The reason for the breakdown of our fish may be due to separators. The reason for the yellowing of our lawns is that it does not get enough sunlight. Our water was polluted more quickly and our fish died because we didn't choose our water plant.*

As seen in this excerpt, the pre-service science teachers listed the changes in their ecosystems first in the report they wrote and then recorded their opinions and predictions on these changes. When this paragraph is analyzed, the preservice teachers' reasoning for the fragmentation of the fish may be due to inference-based observations (the reason for the yellowing of our lawn is not getting enough sunlight) and the awareness of one's own mistakes. Although they have critical thinking skills, they do not effectively transfer these skills to their reports. For example, at the beginning of the paragraph, they shared their observations that the lawns were yellowing, and tried to explain their reasoning about this observation after three sentences. This situation is interpreted as the lack of critical thinking skills of pre-service teachers.

Another interesting finding from the analysis of the data was that several skills related to "prediction," "critique of data," "lack of prejudice bias," and "clarification" were either little or not at all coded in the initial and final analyses. In the interviews, the preservice teachers were also asked whether they critiqued their observations in the reports. It was seen that most of the preservice teachers thought that they did not need to revise their observation results or repeat the observations. This is probably the reason why the "critique of data" code was not present in the student reports. Additionally, in discussions with the other coders supporting the analysis of data in the context of the research, it was stated that the "lack of prejudice bias" code was not a skill that students could reflect in their reports. Therefore, the lack of this code in the reports should not be interpreted as the preservice teachers not having this skill.

Discussion and Conclusion

This study aimed to examine how can pre-service science teachers reflect their critical thinking skills in their writings and how would a classroom practice integrated into the biology laboratory course affect pre-service science teachers' writing skills. For this purpose, an application was designed and applied within the scope of the biology laboratory course. The results show that

pre-service science teachers had difficulties in reflecting their critical thinking in their writings, but it was determined that they were able to improve themselves in the process. In this study, not enough evidence was found related to critical thinking skills during the implementation process. However, this should not be interpreted as the preservice teachers' lack of these skills, but it should be considered as not being able to fully utilize these skills due to the absence of an appropriate learning environment. If an appropriate learning environment is provided, preservice teachers can use and improve their critical thinking skills and acquire writing skills through experience. Copriady et al. (2018) found that the studies conducted in the laboratory helped to improve students' conceptual development, cognitive skills, and metacognitive competencies. Findings obtained within the scope of this current research support this result.

It is stated in the literature that the writing experience enables students to understand science and scientific practices beyond their class experiences (Prain, 2006; Norris & Phillips, 2003). According to the current study, although some of the pre-service teachers can reflect critical thinking skills in their writings (such as reasoning and objective attitude), it was found that the preservice teachers have deficiencies in not only thinking critically but also writing critically. This finding is in line with the finding by Çiğdemoğlu at al. (2017) that pre-service science teachers had difficulty identifying scientific problems and refuting their claims while writing their reports. Similarly, Norman and Spencer (2005), stated that most pre-service teachers don't feel efficient in academic writing experiences.

In this research, some of the pre-service science teachers stated that they did not know what they needed to consider when writing their reports, and in some student groups, it was observed that the preservice teachers could not reflect their in-group discussions in their reports. One of the main reasons for this may be the lack of knowledge of pre-service science teachers about writing (Draper et al., 2000). Other findings related to this situation stated by McDermott and Kuhn (2011) that, college students cannot make the assumptions they make continuously in the writing process. For this reason, it is considered that the application developed within the scope of this research, not only supports the writing skills of preservice teachers but also helps them to express their assumptions in writing. In parallel with this, Cremin and Oliver (2017) showed that pre-service and in-service training programs are important for teachers to improve their writing skills and perceptions and increase their self-confidence.

One of the interesting findings of the research was the presence of very little evidence concerning "critique of data," "lack of prejudice bias," and "use of prior knowledge" skills obtained from the literature related to the writing skills of preservice teachers. Although many researchers in the literature (Case, 2005; Kennedy, et al., 1991; Willingham, 2007) showed that the use of prior knowledge is a crucial element in individuals' critical thinking skills, the preservice teachers in this research were not able to clearly explain how they used their prior knowledge in their reports, although unstructured interviews showed that they had prior knowledge. This indicates that the pre-service teachers were not aware of the importance of referring to this knowledge in their reports. This may be directly related to their lack of writing skills. Concerning the "lack of prejudice bias" skill, by considering the criticism mentioned above of the independent coders supporting the research, it can be stated that the absence of this skill may be interpreted as a weakness of the classroom practice. For this reason, it is suggested that critical thinking skills should be defined before designing classroom applications and the boundaries of the research should be drawn. Finally, the fact that no evidence of "critiques of data" was identified is an important consequence of the research. In this research preservice teachers preferred to transfer the raw data directly instead of saying something new by criticizing the data they obtained. Similarly, McDermoth and

Kuhn (2011) found that college students perceive writing tasks as more information transfer rather than providing new knowledge. This situation once again reveals the need to focus on the development of writing skills in teacher education.

Although there is a great deal of literature on critical thinking skills, to date, no concrete evidence has been found that critical thinkers can write critically. For this reason, it was not predicted whether there is a relationship between the critical thinking skills of the pre-service science teachers who participated in the study and their writing skills. Since the critical thinking skills of pre-service teachers were not measured with a standard test before the research, considering the purpose and quality of the research, the results should not be interpreted directly as the critical thinking levels of the pre-service science teachers. One of the limitations of this study, and even the most important, is that the obtained results do not allow a direct link between critical thinking and writing and that there is no clue about the critical thinking skills of pre-service science teachers before the process. As stated in the methodology section of the article, necessary measures were taken to prevent the research from being influenced by the academic knowledge level of the pre-service teachers and the researcher's prejudices. Participation in the survey was voluntary; hence, there were no concerns regarding the reliability of the data collected from pre-service teachers.

The overall results showed that the classroom practice conducted within the scope of this study improved the writing skills of pre-service science teachers. Although the results obtained cannot be directly attributed to preservice teachers' developing critical thinking skills, it is possible to say that the application developed is beneficial because it encourages students to use the innate characteristics they have. Miatin and Wiedarti (2019) revealed that although students improve their writing self-efficacy, they may be reluctant to write. However, the findings of this study showed that the applied method also increased the student teachers' motivation to write. This finding is consistent with the finding that there is a positive and significant relationship between students' writing skills and writing motivations (Nasihah & Cahyono, 2017). From this point of view, learning environments that allow prospective teachers to use their critical thinking skills frequently offer opportunities for the development of these skills.

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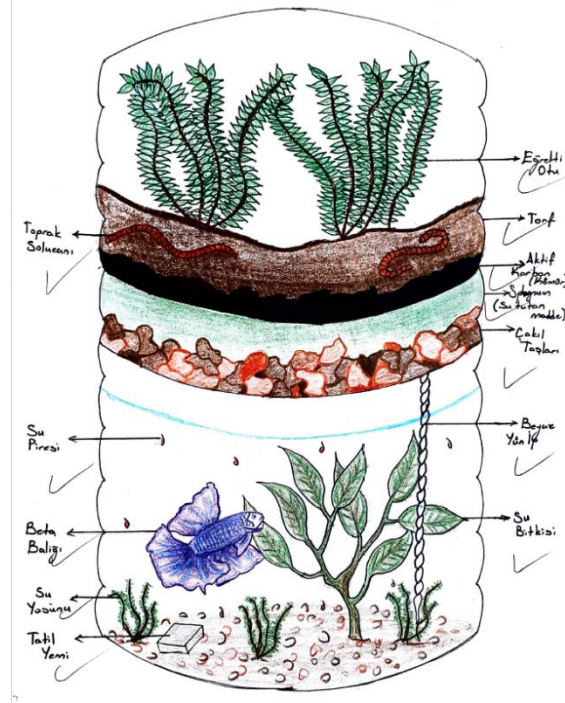
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APPENDIX
Examples of Bottle Ecosystem, Ecosystem Design, and Student Report