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An inquiry and context-based activity supporting lifelong learning: Enzymes in Daily Life

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ABSTRACT

This research evaluated the effect of guided inquiry approach-based laboratory activity within the scope of lifelong learning, in which daily life context is used, on developing pre-service science teachers' learning processes. The study groups for the research consisted of six pre-service science teachers who were seniors in the science education department at a university in the west of Turkey. The holistic single-case design was used as the research method in this study. One of the topics related to enzymes we encounter in many areas of daily life is the concept of enzymatic browning. In this study, starting from a daily life context, an activity that includes the chemical change emphasis underlying the enzymatic browning event and the factors affecting the work of enzymes is discussed. In this context, the guided inquiry learning approach, in which the hypothetico-deductive reasoning cycle is used in laboratory practices in teacher education, is based on the activity. At the end of the activity, experiment reports, science journals, and concept maps were evaluated. As a result of the evaluation, it was seen that the students not only designed scientific research and tested their hypotheses consistently and accurately but also obtained subject gains related to enzymes and chemical change. Since it is understood that the activity supports lifelong learning in terms of both the skills developed and the ideas reflected by the pre-service teachers, using similar practices in teacher education can be recommended.

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INTRODUCTION

Due to the changing social, economic, and cultural conditions in the 21st century, the competencies expected of individuals are also changing. In this context, the individual can adapt to changing social needs, follow developments, and constantly improve himself. The concept of lifelong learning is essential in this context. Lifelong learning is "all purposeful learning activity undertaken on an ongoing basis to improve knowledge, skills, and competence" (Commission of the European Communities, 2000). Since lifelong learning focuses on continuous learning, problem-solving, and adaptation to social and physical environments, it is seen as the driving force behind development and transformation (Vargas, 2017). For this reason, Lifelong Learning has been the main emphasis of education policies in many countries (English & Carlsen, 2019, p. 207). According to Dolan (2012), these education policies include teacher education, and lifelong learning has become an essential element in teacher education.

We can say that a change in basic assumptions has taken place in our century, which includes the transition from teaching to learning, from there to learning by doing, and from there to lifelong learning. The expected outcome of this is to create a learning society (an information society). Lifelong learning, which includes all learning activities experienced, covers all formal, informal, and non-formal education. According to McLean (2022), lifelong education consists of four broad categories of activities: early childhood education, primary and secondary education, tertiary studies, and adult education. It is claimed that lifelong learning, which covers the whole spectrum of learning, including formal, informal, and non-formal learning, requires linking learning outcomes from different environments and contexts (Laal & Salamati, 2012). Similarly, according to Dinevski & Dinevski (2004), lifelong learning refers to all activities conducted throughout life to develop knowledge, skills, and competencies. These include all forms of learning: formal (courses and exams), non-formal (without exams), and informal (without courses or exams).

If lifelong learning is to be achieved realistically, the basic principles of lifelong learning must be adopted by both formal and non-formal education (Dolan, 2012). Integrating and contextualizing learning with everyday tasks should be flexible, and this flexibility should include learning anywhere and anytime, extending to the spatial and temporal dimensions (Friesen & Anderson, 2004). According to Aspin and Chapman (2000), who introduced the concept of lifelong learning for everyone, this process starts in preschool and continues with formal and non-formal education and beyond. It includes all formal and informal learning experiences at home, work, universities, and other educational, social, and cultural environments, institutions, and the community. It is a complex and multifaceted process that continues throughout life. As it is understood, one of the essential areas of this complex process is higher education. In this direction, from past to present, both in universities (Dinevski & Dinevski, 2004; Gelpi, 1991; Hernández-Encuentra & Sánchez-Carbonell, 2005; Longworth, 1997; Walters & Watters, 2001) and especially in teacher education (Beernaert, 1997; Dolan, 2012; Ordonez, 2005; Tatık & Ayçicek, 2022), studies have been conducted on the subject. Dolan (2012) suggests that teacher education programs should benefit from the theory and practice of lifelong learning.

Lifelong learning is essential for pre-service teachers' education programs (Finsterwald et al., 2013; Klug et al., 2014). In this context, pre-service teachers are expected to learn to be committed to lifelong learning and teach their students to learn independently (Siribanpitak, 2018). This perspective requires pre-service teachers to be committed to constructivism. Two aspects should be considered in the design of lifelong learning environments: (1) motivation toward education and (2) the ability to apply what has been learned successfully in concrete learning situations (Finsterwald et al., 2013; Weinstein & Hume, 1998). For this reason, inquiry and context-based activities are thought to effectively gain a perspective on lifelong learning.

Enzymes are specific biocatalysts in protein structure that coordinate the reactions in living organisms. They have the property of accelerating reactions much more than chemical catalysts (Alpat, 2017). Enzymes are vital to living organisms (Vartak et al., 2013). However, in science education, few studies have examined students' learning about enzymes (Bilen et al., 2016). According to the research of Sinan et al. (2006), which is one of these studies, university-level science students have important misconceptions about enzymes and the factors affecting enzymes. Some of the participating students stated that inhibitors are substances that accelerate the reaction. According to the authors, the reason for this misconception is that the concepts of catalyst and inhibitor are confused. The students in the study mentioned above show that they do not fully understand this concept by claiming that enzymes only work at the optimum temperature value and are not active outside of this value. There are other studies (Linenberger & Bretz, 2012; Selvi & Yakışan, 2004; Sinan et al., 2006) that examine students' understanding of enzymes and reveal that there are misconceptions.

One of the daily life-related issues related to enzymes is the concept of enzymatic browning. It is accepted that the browning/browning reactions that occur in raw fruits and vegetables due to abiotic stresses (such as excessive light, drought, or cold) are caused by the enzymatic oxidation of phenolic compounds (Adams & Brown, 2007). Similar darkening occurs in situations such as cutting fruits and vegetables for different purposes and peeling their skins, a situation we frequently encounter daily. The enzyme catechol oxidase mediates the enzymatic browning of fruits such as apples. Pyrocatechol is the substrate of the enzymatic reaction and is an antiseptic compound that it releases when it penetrates the outer layer of the fruit (Cole et al., 2020). When the enzyme interacts with pyrocatechol, the oxidation event, which we call browning, occurs in the fruit. As it is understood, when the apple is cut, the accumulation of phenolic compounds first occurs, followed by enzymatic oxidation and enzymatic browning with the change of tissue color. Sinan (2012) explains the production of dark-colored pigment molecules, which cause the familiar browning of vegetables, fruits, and mushrooms as they age or rot, through the enzyme polyphenol oxidase and states that it catalyzes a redox reaction in which various phenolic compounds are oxidized.

In the case of enzymatic browning, enzymes, the subject of biology, and chemical changes and reactions, which are the subject of chemistry, intersect. It is easy to present this intersection from different angles. We can show this when explaining the structure of enzymes in daily life contexts or describing the properties of chemical change. Enzymes are like chemical catalysts in a chemical reaction and are structures that help speed up biological/biochemical reactions inside and outside the cell (Gurung et al., 2013). Biochemical reactions are indicators of chemical change, one of the most critical issues for students to understand.

Regarding chemical reactions, students have the misconception that chemical reactions cannot occur unless there is an external intervention, such as heating (Ceylan & Geban, 2010). According to the study of Hesse and Anderson (1992), among the most common problems among students who cannot predict or explain mass changes in chemical reactions is the tendency to treat chemical changes, such as rusting, as physical changes in form or state. So, one of the ways to understand chemical reactions and relate them to daily life based on context lies in understanding the indicators of chemical change by observing them at the microscopic and macroscopic levels. A change in a substance's physical or chemical properties can cause a change in the wavelength of light that the atom, ion, or molecule absorbs at the molecular level and, as a result, change the substance’s color. In this context, when an effect is made on a substance, the color change determined by observation is based on a physical change in some cases and a chemical change in others (Ergül et al., 2020). It is essential to understand the subject of chemical change; even according to Hesse and Anderson (1992), chemistry is a science whose primary purpose is to describe and explain chemical changes.

The intersection of chemistry and biology is biochemistry. One of the principal areas of biochemistry is enzymology, which includes the structure, kinetics, and regulation of enzyme activity

(Sinan, 2012). We can establish a similar association between chemical reactions and enzymes because chemical reactions and transformations occur during enzymatic activity events. Enzymes are essential biomolecules for numerous life-sustaining chemical transformations (Gurung et al., 2013). Chemistry teaching is based on models representing basic molecular processes, structures, properties, interactions, behaviors, and physics that drive phenomenological chemical change (Bennie et al., 2019). One of the mentioned phenomenological chemical change events is the reaction in which enzymes take place. Therefore, there is a need to diversify the instructional experiences that will increase students' association with and understanding of the concepts in question and to use diverse ways to understand why the concept should be known, that is, to understand the essence of the context. One of the easiest ways to do this is to associate it with daily life. According to Demoranville et al. (2020), combining chemical concepts with real-world applications has increased retention, student attitudes, and performance. According to Slapničar et al. (2018), emphasizing that it is crucial to awaken students' interest in learning chemistry to prevent misconceptions in chemistry and revealing that students have misconceptions about many chemistry subjects, including chemical reactions, teachers can arouse students' interest by applying context and inquiry-based chemistry education. Besides this, it can be stated that daily life events are one of the most basic context examples and can be used in the questioning process.

One of the important aims of chemistry education is to enable students to apply and use scientific concepts to improve their understanding of daily life events and to explain events that occur in daily life (Kingir et al., 2013). As students form their views on concepts related to chemistry, they can be influenced by examples that have real-life counterparts. Many students in the study of Hesse and Anderson (1992) preferred explanations based on analogies associated with everyday events (for example, rust and rotting) rather than chemical theories. It is also known that persuasive information is usually obtained from objective observations and empirical experiences (Ergül et al., 2020). At this point, the easiest way to experience objective observations is through laboratories.

The laboratory is important because it allows students to learn science subjects and concepts directly related to daily life more effectively and meaningfully and provides real-life experiences (Bilen et al., 2016). The authors explained the laboratory this way. They examined the effectiveness of action research based on the predict-observe-explain technique in the science laboratory applications course on pre-service teachers' understanding of enzymes. As a result of the activities, it was concluded that the pre-service teachers had difficulties learning the subject of enzymes and had severeal misconceptions. Laboratories, which are effective in eliminating these misconceptions and embodying abstract topics such as 'enzymes' or 'chemical reactions,' are experimental classroom environments. According to Schmitz et al. (2022), the common feature of experimental classes is using real-world problems as starting points. This further contributes to reducing the abstractness of specific topics. One of the laboratory forms in which real-world problems are used as the starting point is the hypothetico-deductive reasoning cycle proposed by Lawson (2000), which begins with a causal question, continues with hypothetical propositions, and reaches conclusions through experimentation. In this cycle, a holistic approach is applied, and the analytical reasoning process is put to work. If a holistic approach to biological systems is not applied, according to Lazarowitz and Penso (1992), who state that the student may begin to assume that all information is on his or her own, determining the level of operational reasoning required for the student to assimilate and embed the concepts being taught is essential in terms of using new knowledge more analytically. In addition, according to the researchers, one of the most abstract concepts in the biology curriculum is enzyme activity. Therefore, it is crucial to realize the subject of enzymes in an effective research environment in which the hypothetico-deductive reasoning cycle is used. According to Vartak et al. (2013), who state that effective scientific research consists of three essential components, these components are: (1) applying concepts; (2) going through various processes such as observation, classification, correlation, and procedural understanding; and (3) applying skills. One of the best examples of an instructional environment where these essential components can be found together is the guided inquiry learning approach-based laboratory applications. The positive effect of the guided inquiry learning approach used in laboratory practices on student achievement has been demonstrated by many studies (Lazonder & Harmsen, 2016; Margunayasa et al., 2019).

Enzymes can affect our perspective, making sense of the events we encounter and experience in several parts of our daily lives. The related literature studies suggest using a context-based learning approach in teaching enzyme subjects (Demoranville et al., 2020) and the positive effects of a guided inquiry approach on student achievement (Lazonder & Harmsen, 2016; Margunayasa et al., 2019). For this reason, an activity was developed in this study to teach enzymes. In this context, the research question of this study is:

To examine the effect of a guided inquiry approach-based laboratory activity within the scope of lifelong learning using the context of daily life on the development of students' learning processes.

Theoretical Framework

The context-based learning approach is one of science education's most prominent ideologies, dating to the 1980s (Sevian et al., 2018). Bennett et al. (2007, p. 348) define the context-based learning approach as "the approach in which science contexts and practices adopted in science teaching are used as a starting point for the development of scientific ideas." Contexts, central to this approach, help students make sense of scientific concepts, laws, and principles (De Jong, 2006). The interaction expressed as "Why does this concept need to be known?" between context and science concepts (King, 2012, p. 3) is the essence of the context-based learning approach. It is stated that a realistic and compelling context is seen as a starting point for learning science and thus gives importance and meaning to the science content (Taconis et al., 2016). Daily life events, original scientific activities, or social dilemmas and debates are appropriate examples for contexts (Gilbert, 2006). In context-based learning environments, concepts are learned and derived from context. On the other hand, transfer to other contexts is usually organized in context-based learning environments by giving examples from other contexts and situations (Gilbert, 2006; Parchmann et al., 2006).

Context-based learning environments support students' understanding of their world by equipping them with scientific knowledge and skills that support a deeper understanding. One of the most critical features that context-based learning environments should have from an educational point of view is that they are organized from a constructivist perspective (Pesman & Ozdemir, 2012). This perspective considers a process in which learners construct meaning from their experiences rather than copying information from other sources (de Putter-Smits et al., 2013). For this reason, inquiry-based teaching methods, techniques, and strategies can be frequently used in designing context-based learning environments (Karsli et al., 2019; Ultay & Calık, 2012).

The National Science Education Standards published by the National Academy of Sciences in the United States define inquiry as a multidimensional activity at the center of science education. The same report states that these activities should be included in the science curriculum in relation to students' lives, organized around questioning, and in connection with other school subjects (NRC, 1996). As seen in Table 1, inquiry learning can be applied at four distinct levels, depending on the amount of guidance the teacher provides (Bell et al., 2005; Blanchard et al., 2010).

Table 1. *Levels of inquiry*

Levels	Source of the Research Questions	Source of Data Collection Methods	Source of Interpretation of Results
Level 0: Verification	Given by teacher	Given by teacher	Given by teacher
Level 1: Structured	Given by teacher	Given by teacher	Open to student
Level 2: Guided	Given by teacher	Open to student	Open to student
Level 3: Open	Open to student	Open to student	Open to student

In the zero-level verification inquiry, there is teacher guidance at all stages of an experiment (forming the research question, applying it, and interpreting the data). In the first level of structured inquiry, students are given a research question. Teacher guidance is provided while experimenting with which materials to use to solve this research question. The students then try to solve the problem by experimenting with themselves. In second-level guided inquiry, students are given only the research question. Students are responsible for formulating hypotheses from that research question, designing experiments to evaluate their hypotheses, and interpreting the experimental results. In the third level of open inquiry, students are expected to formulate their problems and design the entire process to reach a solution (Bell et al., 2005; Vroom et al., 2020). Although the level of guidance to be given to students is related to their age and cognitive development levels (Bell et al., 2005), it is seen that the effects of structured and guided inquiry learning activities on student success are more favorable than confirmatory inquiry activities in studies conducted in this area (Blanchard et al., 2010; Margunayasa et al., 2019). In addition, it is seen that the effects of structured and guided inquiry learning activities, in which students are provided with a certain level of guidance, are more favorable than open inquiry activities without any guidance (Alfieri et al., 2011; Lazonder & Harmsen, 2016; Minner et al., 2010; Yulanti et al., 2020). The social constructivism theory can explain this situation based on Vygotsky's work. According to the theory, appropriate guidance given by an expert is a way of constructing complex knowledge structures. More permanent, stronger structures can be built in the final product with suitable temporary structural supports, and at some point, no longer any support is needed (La Braca & Kalman, 2021). Based on these explanations, the study used guided inquiry at the second level, in which a certain amount of guidance was given to the students.

METHOD

Research Design

Based on the purpose of the research, the holistic single case design, which is one of the qualitative research designs, was chosen to examine the effect of the guided inquiry approach-based laboratory activity within the scope of lifelong learning, in which the daily life context is used, on the development of the learning processes of the students. Since a particular case and a single analysis unit were studied in the research, a holistic single-case design was adopted (Yin, 2018). In this research, we apply a guided inquiry approach based on laboratory activity in which daily life context is used. In this case, the change in the student's learning processes was examined in depth. The case study is a method that allows in-depth analysis by focusing on real-life-related phenomena, events, situations, and individuals (Creswell, 2003).

Participants

This research was conducted with 3rd-grade pre-service science teachers studying at a state university within the scope of the Science Teaching and Laboratory Practices course. This course aims to provide pre-service science teachers with the ability to design and implement experiments with simple and inexpensive materials on science subjects in the secondary school curriculum. In the activity designed with this aim in mind, the concept of chemical change, discussed at the secondary school level, was examined by associating it with the enzyme concept. Because the activity is held remotely through the Microsoft Teams Program, both for the course and the conditions of the Pandemic, an activity that can be done at home using simple and inexpensive materials has been developed. Four of the participants are girls, and two are boys. The academic achievement averages of the participants vary. Detailed information on these indicators can be seen in Table 2. In order to ensure the confidentiality of the names of the participants, their real names were kept confidential during the coding and reporting of the qualitative data. Participants were given codes from P1 to P6, each representing a participant.

Tablo 2. *Participant profile*

Student code	Gender	Academic achievement averages
S1	Boy	2.96
S2	Boy	2.86
S3	Girl	3.22
S4	Girl	3.37
S5	Girl	2.80
S6	Girl	2.80

Research Instruments

This study used experiment reports, science journals, and concept maps prepared by the students to evaluate the effect of the guided inquiry approach-based laboratory activity within the scope of lifelong learning, in which the daily life context was used to develop students' learning processes. In this context, data triangulation was made by using multiple measurement tools for the same purpose (Cohen et al., 2005), and the study was detailed.

Experiments Reports

One way to evaluate the effect of the applied activity on the development of students' learning processes is through the reports prepared before and after the experiment. Experiment reports, which can show the extent to which the student has mastered the conceptual and process knowledge contained in the experiment, are also expressed as a learning tool used for scientific communication and knowledge construction (Rijlaarsdam et al., 2006). The experiment reports in this study were designed by considering the steps of the hypothetico-deductive reasoning cycle that Lawson suggested being used in science lessons (Lawson, 1995).

Science Journals

One way to evaluate the effect of the applied activity on the development of students' learning processes is in science journals. Science journals provide information about students' learning competencies, experiences, and difficulties in teaching science concepts (Korkmaz, 2004). Science journals are effective reflective individual products that can give direct information about life. Considering the potential power of the science journals, they were used as a data collection tool in the study to understand and evaluate the student's learning processes. In this way, it was possible to evaluate the status of the learning processes related to the inquiry and context-based activity, which included an emphasis on the chemical change underlying the enzymatic browning event and the factors affecting the functioning of enzymes, from the science journals prepared by the students. Each of the students created a science journal for the activity. The students were given no limits, content information, word limits, or questions to create science journals, and it was left entirely to them.

Concept Maps

One of the ways to evaluate the effect of the applied activity on the development of students' learning processes is to evaluate the concept maps they have created. These graphical tools effectively show students' cognitive schemas about the related topic, concept, or process, how they construct the information about the topic in their minds, idea generation processes, and learning structures. It can be stated that concept map applications in science teaching provide students with an opportunity to organize and visualize the relationships between key concepts systematically and to reflect on the connections between the concepts they have learned (Novak & Cañas, 2006). Concept maps provide a picture of the mental structure of the related science subject, allowing students to make associations between concepts and create indicators for evaluating these associations (Author, 2021, p. 248). The students created a concept map in their pre- and post-experiment reports within the research process they started after they were given the problem scenario.

Process

In this section, information about the development and implementation processes of the activity is presented.

The development process for the activity

The study was carried out in the Science Teaching and Laboratory Practices course. The course in question is one of the mandatory courses in the Science Teaching Program in Turkey. In this context, the related course has been designed using laboratory practices based on a guided inquiry learning approach in which a hypothetico-deductive reasoning cycle is used. Within the scope of the course, 12 different activities were designed. Each activity takes two weeks to complete. Within the scope of this study, an activity designed to address the factors affecting the functioning of enzymes will be presented.

The completion of the color-changing fruits and vegetables activity covers two weeks. In the first week, a problem scenario taken from daily life regarding enzyme activities is presented. Students are asked to form their hypotheses regarding the solution to the problem in the scenario and to design an experiment to test one of these hypotheses. Four days after this stage, the students send the pre-experiment reports they prepared through the Microsoft Teams program to the course's instructor (also one of the authors of the research). The instructor gives students feedback through the same program. Students are asked to make the necessary corrections before the experiment. In the second week, the experiments designed to test the hypothesis are applied by the students. The students are expected to reach a result by comparing the predicted results with the observed results. After this stage, the lecture is concluded by interactively introducing the concept discussed by the instructor and associating it with daily life. After the lesson, the post-experiment reports prepared by the students are evaluated by the instructor, and the necessary feedback is given through the Microsoft Teams program. In the study, the hypothetico-deductive reasoning cycle was used to teach the lesson (Lawson, 1995, p. 115). This cycle is shown in Figure 1.

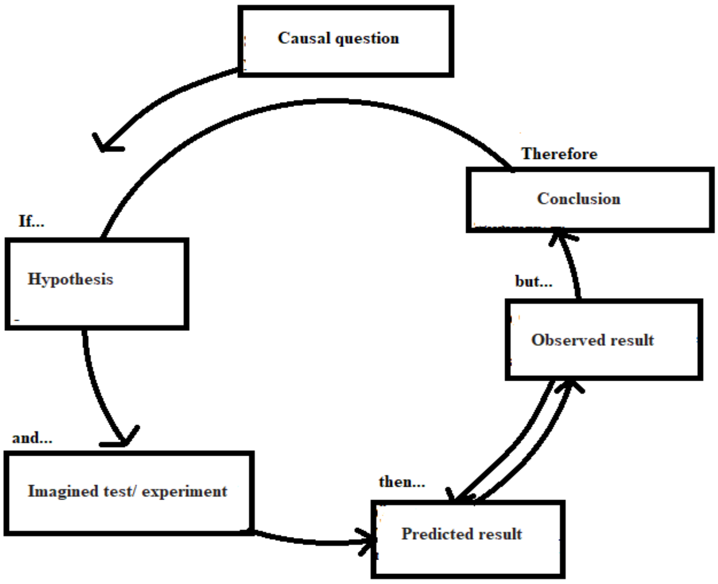

Figure 1. *Hypothetico-deductive reasoning cycle*

Note. From Science Teaching and The Development of Thinking (p.115), Lawson, A. E., 1995, Wadsworth/Thompson Learning

The implementation process of the activity

Phase 1: Scenario presentation and student opinions

At this stage, the instructor presented a problem scenario taken from daily life regarding enzyme activities. The visuals and scenario presented in the scenario are given below.

Figure 2. *The visual presented to the students in the scenario*

"Almost everyone, especially mothers, notices that some fruits and vegetables change color after they are peeled or cut. The darkening and color changes experienced after cutting fruits and vegetables are due to one of the enzymes, polyphenol oxidase. The enzyme in question, which can be called PPO in short, takes the oxygen in the air and provides a reaction with the chemical called tannin in the fruit or vegetable. This reaction creates browning. You are expected to identify hypotheses regarding the browning problem of cut fruits and vegetables and to solve this problem by testing these hypotheses."

At this stage, the students were asked their opinions about the causes of this problem. The examples of student opinions are given below:

Student 3:

"I've been thinking about things that might affect enzyme activation. For example, we can store apples in the freezer before they turn black. Drying the apples and removing their juice prevents them from darkening. Getting the tannin in apples out is impossible, so we have to think about oxygen contact and enzyme activation."

Phase 2: Preparation before the experiment

At this stage, the examples from the students' pre-experiment reports on the hypotheses proposed by the students regarding the solution to the problem, the experimental setups they designed to test these hypotheses, and the explanation of the predicted result of the experiment will be presented.

Student 4:

“My hypothesis(s) for this experiment are:

If the fruit is placed in water after cutting and its contact with air is prevented, it will not darken.

If lemon is applied to the cut part of the fruit, the contact of tannin and oxygen is prevented, and it does not turn black.

If we bake the fruits, the enzymes will be destroyed by heat, and the fruit will not darken.”

The hypothetico-deductive reasoning cycle I used in the experiment is below:

Causal question: How does the cut fruit not darken?

Hypothesis: If the fruit is placed in water after cutting and its contact with air is prevented, it will not darken.

Experiment: The fruit is divided into two. Half put in water; half left outside. The browning times of these apples are calculated.

Predicted result: Fruit placed in water does not darken."

Phase 3: Making a correlation between the predicted and actual results by testing the student hypotheses.

At this stage, there will be student explanations about the realization of the experiment they designed to test the hypotheses they propose regarding the solution to the problem and the correlation between the predicted result of the experiment and the actual result obtained because of the experiment.

Student 5:

Instructor: Can you explain the procedures you followed in this experiment?

“I sliced apples. I covered half of the apple with aluminum foil and left the other uncovered.

Instructor: Can you explain the dependent, independent, and control variables in this experiment?

“The independent variable(s) in this experiment: The contact of the apple with oxygen (whether there is foil on it)

Dependent variable(s) in this experiment: Darkening of the apple

Variable(s) controlled in this experiment: Apple variety, room temperature."

Instructor: Can you explain the situation you observed in this experiment?

The part of the apple that is in contact with oxygen (covered with aluminum foil) is slightly darkened. The other half is blackened. Oxygen caused the apple to darken. The experiment photo of the student is shown in Figure 3.

Figure 3. *Student 4 experiment photography*

Instructor: Can you explain the evidence supporting or refuting your hypothesis in this experiment?

“Oxygen exchange and late browning time of the cut apple supported my hypothesis.

Instructor: What is your conclusion from this experiment?

"The polyphenol oxidase enzyme found in apples reacts with oxygen and creates a reaction with a chemical called tannin. This reaction also causes a darkening. Enzymes cause chemical changes by lowering the activation energy. Browning of the apple can be prevented for a while by interrupting the oxygen exchange.

Instructor: In which situations can you use the result of this experiment in your daily life?

"After making the cake, pouring honey on the banana that I will use during the decoration process slows down the enzyme activity and makes the banana darker later. If I cover the apple, I cut in half to eat later with an oxygen-proof material, I can carry it with me for a longer time before it gets dark. Lemon slows down enzyme activity. By squeezing lemon on the quince, I can make the quince darken later. When choosing skin products to eliminate discoloration and color unevenness in my skin, I prefer those with vitamin C. Because vitamin C accelerates the production of collagen and elastin in the skin, helping to eliminate the color unevenness of the skin. "

Phase 4: Term introduction

At this stage, the students were first asked to summarize the results they obtained from their research so that they would explain and scientifically label the concepts they learned. Then, the properties of enzymes and the factors affecting the work of enzymes were discussed by the instructor, and the subject was reinforced with daily life examples related to the subject. However, at this stage, students were asked to design thought experiments and share them with the instructor to contribute to connecting the subject with daily life. A sample thought experiment prepared by the students is given below.

Student 4:

“While Zehra is eating quince and oranges in her room, her mother calls out and asks her to hang the laundry. So Zehra thinks about eating her fruits when she returns to her room. When Zehra returns to her room an hour later, she sees that the quince has darkened, but the orange remains the same. She thinks about the reason for this situation. What do you think is the reason for this?

My hypotheses:

While quince contains polyphenol oxidase enzyme, orange does not darken because there is no polyphenol oxidase enzyme in oranges.

Orange does not darken because it is colder.

Orange does not darken because it contains vitamin C.

The hypothetico-deductive reasoning cycle I used in the experiment is below:

Causal question: Why does the orange not darken while the quince turns black?

Hypothesis: Orange does not darken because it has vitamin C.

Experiment: The quince is divided into two. Orange juice is applied to half of it, and nothing is applied to the other half. Browning times of these quinces are observed.

Predicted result: The quince part with orange juice darkens later than the other part of the quince.

Observed result: The quince part with orange juice darkened later than the other.

Conclusion: Vitamin C affects the functioning of enzymes."

Data Analysis

The researchers prepared a scoring guide to evaluate the experiment reports prepared by the students before and after the experiment. While the first two of the themes of the scoring guide, which was created in parallel with the planning and managing steps of scientific research, were included in the pre-experiment reports of the students, the others included the sections in the post-experiment reports. The themes of the scoring guide consist of what the students did during the activity. When evaluated in terms of items, higher scores were given, especially to scientific process skills such as creating and performing the hypothetico-deductive reasoning cycle and making comments or transforming data into different forms. Another item group with a higher score is the items that associate the subject with daily life (presenting a daily life example and creating a thought experiment). The scoring guide developed for the color-changing fruit and vegetable activity is given in Table 3.

Table 3. *Experiment reports scoring guide*

Themes	Items	Item Scores
Problem statement	1. Student creates research problem(s) appropriate to the scenario	1
	2. Student proposes a reasonable hypothesis	2
Planning	3. The student creates a hypothetico-deductive reasoning cycle suitable for a hypothesis he/she chooses*	3
	4. The student supports the cycle created by theoretical research	1
Control of variables	5. Student defines a dependent variable(s)**	1
	6. Student defines an independent variable(s)**	1
	7. Student defines variable(s) under control**	1
Application	8. The student performs an experiment whose hypothesis can be reasonably tested and whose variables are appropriately controlled	3
	9. The student defines the steps of the experiment he/she performs with at least three steps	1
	10. The student shows the shape of the experimental setup by drawing, photographing, and similar ways	1
Presentation of evidence	11. Student explains the results of the observation	1
	12. Student explains the recorded data	1
	13. The student transforms her/his findings into tables, graphs, and similar forms.	2
Reflection	14. Student interprets experiment results	2
	15. Student compares hypothesis-outcome	1
	16. Student specifies the expression of achievement in terms of the subject area	1
	17. Student indicates possible experiment errors	1
Associating with daily life	18. The student presents examples that relate experimental results to daily life***	2
	19. The student designs a thought experiment based on daily life examples	2
	20. Student proposes a reasonable hypothesis for the thought experiment	1
	21. The student creates the hypothetico-deductive reasoning cycle by her/his hypothesis	3
Total point		32

*In item 3, the student is expected to create the cycle contextually and formally. If there are contextual deficiencies, it is evaluated as 1 point out of 3 points; if there are formal deficiencies, it is evaluated with 2 points out of 3 points.

**Variables were defined in items 5, 6, and 7, but no points were given if they were incorrect.

***In item 18, if the daily life example is not clear enough or only one example is used, 1 point is given.

Student journals were analyzed using descriptive analysis. Descriptive analysis makes complex situations understandable by drawing a picture of a situation or event (Punch, 2005). In the process, science journals were first evaluated in general, the probabilities of the themes were extracted, and evaluations were made. Later, the diaries were analyzed separately by the researchers; the codes were extracted and gathered under specific themes. The researchers determined both the agreed and the non-compromised codes by comparing the codes they created (regarding compatibility with the themes). Then, the final codes were decided by discussing the points of disagreement. The findings are presented in tables by quoting from student examples.

The concept maps of the students were evaluated using rubrics. The rubric comprises five sub-dimensions: 'proposition construction,' 'cross-link,' 'examples,' 'linking words or attachments,' and 'direction of link arrows.'These dimensions were created by considering the principles of concept maps consisting of propositions, cross-links as indicators of relational configurations, examples for associating the subject with daily life, and structural content principles. The success levels of the rubric were rated as 'limited performance,' 'recommended performance,' and 'successful performance.'The researchers first analyzed concept maps separately according to the rubric created. Afterward, the points of disagreement were discussed, and the final scoring was decided. The developed rubric is presented in Table 4, and the rubric evaluation results are presented in supplementary material 1.

Table 4. The rubric used in the evaluation of students' concept maps

Criteria	Achievement levels: limited performance (1)	need to improve performance (2)	successful performance (3)
Proposition	In the concept map, three or fewer propositions containing the subject's key concepts were created.	In the concept map, 4 or 5 propositions containing the subject's key concepts were created.	In the concept map, six or more propositions containing the subject's key concepts were created.
Cross-link	In the concept map, no cross-linkage was established between the different relational levels of the subject.	There is valid cross-linking between different associative levels of the subject in the concept map, but not significant (in terms of reflecting creative thinking).	In the concept map, there are both valid and important (reflecting creative thinking) cross-links between the different associative levels of the subject.
Examples	In the concept map, no examples were used for the subject's key concepts.	In the concept map, 1 example was used for the subject's key concepts.	More than 1 example was used for the subject's key concepts in the concept map.
Linking words or suffixes	The concept map does not use the link word and/or its suffixes.	The concept map has most link words and/or suffixes, but some are incorrect.	The concept map has all the linking words and/or suffixes and is correct.
The direction of connecting arrows	Most of the directions of the arrows in the concept map are wrong.	1-2 of the direction of the arrows in the concept map are wrong.	The direction of the arrows in the concept map is perfectly correct.

This study used different data sources to ensure credibility (internal validity). In addition, the credibility of the data, the consistency of the data obtained, and the way of using data collection tools in the evaluation process with the relevant literature were checked. According to Yıldırım and Şimşek (2013, p. 270), one of the methods recommended to ensure the transferability (external validity) of qualitative research is the detailed description of the study and analysis process. For this reason, to ensure external validity in the study, the activity development process, implementation process, implementation stages, characteristics of the research sample, research environment, data collection process, and data analysis are explained in detail. In addition, direct quotations from the communication with the students and the daily student discourses were frequently included during the implementation stages of the activity. In terms of ensuring reliability in the study, objective data was created by examining the consensus and disagreement of the researchers in the scoring of the student experiment reports, the analysis of the concept maps in line with the rubric, and the coding of the student journals.

Ethic

Ethical permission for the study was obtained from the Human Research Ethics Committee. (Letter dated 15.09.2020, numbered E.68899 and decision number 26437) In addition, the real names of the students were kept confidential in order to ensure the confidentiality of the students in the presentation of the qualitative data. Students were coded from P1 to P6.

FINDINGS

In this study, the scores obtained from the experiment reports used to evaluate the effect of the guided inquiry approach-based laboratory activity, in which the daily life context was used, on the development of the student's learning processes are given in Table 5.

Table 5. *The scores the students got in the context of the activity scoring guide items*

Themes	Items	Scores	S1 score	S2 score	S3 score	S4 score	S5 score	S6 score
Problem statement	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2
Planning	3	3	3	2	3	3	3	3
	4	1	1	0	1	1	1	1
Control of variables	5	1	1	0	1	1	1	1
	6	1	1	0	1	1	1	1
	7	1	1	0	1	1	1	1
Application	8	3	3	3	3	3	3	3
	9	1	1	1	1	1	1	1
	10	1	1	1	1	1	1	0
Presentation of evidence	11	1	1	1	1	1	1	1
	12	1	1	1	1	1	1	0
	13	2	2	2	2	2	2	0
Reflection	14	2	2	2	2	2	2	0
	15	1	1	1	1	1	1	1
	16	1	1	1	1	1	1	1
	17	1	1	0	1	0	1	1
Associating with daily life	18	2	2	1	2	2	2	2
	19	2	2	2	2	2	2	2
	20	1	1	1	1	1	1	1
	21	3	3	2	3	3	2	3
		Total score	32	24	32	31	31	26

In order to make more practical comments on the scoring guide for the activity in this research process, the scoring guide was divided into levels according to the score ranges, and level definitions were made. The value ranges of the scoring guide according to the levels are given in Table 6.

Table 6. *Value ranges of activity scoring guide by level*

Point range	Level	Level definitions	Indicator-Result
0-8	Level I	Performance with major shortcomings	Students could not test their hypotheses by designing scientific research.
9-16	Level II	Limited performance	The students tested their hypotheses by designing a scientific study, but their designs were contradictory.
17-24	Level III	Performance needing improvement	The students tested their hypotheses by designing scientific research, but there were some deficiencies in some design steps.
25-32	Level IV	Successful performance	Students designed scientific research and tested their hypotheses consistently and accurately.

As shown in Table 6, a student who participated in the research process of the color-changing fruits and vegetables activity scored between 0 and 8, indicating that he could not perform sufficiently in the research steps and had essential shortcomings. It is understood that the student at Level II can test his/her hypothesis in the learning process but show limited performance in the context of themes. It is seen that a student who scores at Level III can test his hypothesis appropriately in the context of the themes mentioned above. However, he has some deficiencies in some steps of the research design. The fourth level shows that the student has performed successfully and that their knowledge is at the desired level. One of the students in this study was at Level III; he tested his hypotheses by designing scientific research, but it was determined that he had some deficiencies in some steps of the experimental design. Other students took place in Level IV. For this reason, it can be said that the students are at the fourth level of the mentioned scoring guide. In other words, students designed scientific research and tested their hypotheses consistently and accurately.

The second way to evaluate the development of the student's learning processes is to evaluate their science journals. The findings regarding evaluating students' science journals are given in Table 7.

Table 7. *Findings on the evaluation of students ' learning with science journals*

Theme	Code	Examples from Students' Science Journals
Thoughts on knowledge acquisition	Find out why fruits turn brown Learning how to prevent the darkening of fruits Learning that apples have polyphenol oxidase enzyme Learning the effect of enzymes on activation energy Learning that vitamin C (lemon juice) slows down the enzyme rate Learning that the enzyme and oxygen react with the chemical tannin in apples Learning that enzymes are affected by temperature Experimental learning ways to prevent darkening How to find out why apples turn black after cutting Learning how polyphenol oxidase enzyme reacts with oxygen Learning that vitamin C prevents the skin from losing water Learning that enzymes are everywhere in our lives Learning that honey prevents darkening by slowing enzyme activation Learning an observable chemical reaction Learn how fruit stays fresh in fruitcakes Understanding the reaction of enzymes with oxygen Learning ways to slow down the action of enzymes Understanding that apple browning is a scientific phenomenon Learning by observing the effect of enzymes on daily events Learning that serum used in skin care contain vitamin C	"In this week's lesson, I learned why fruits turn black and how we can prevent them from turning black. Now I know that I shouldn't leave out the fruits I cut. I knew it was getting dark, but I didn't know why or how." (#S6) "I learned that the polyphenol oxidase enzyme found in apples reacts with oxygen and creates a chemical reaction with the chemical tannin, which causes darkening. I learned the effect of enzymes on activation energy". (#S5). "The information I have learned is really information that I can use for the rest of my life because enzymes are everywhere, and learning and interpreting what happens in fruit was very productive. I learned information that I could use in my own life. (#S1)
Thoughts on the learning process	Finding it effective to repeat the experiment with multiple variables in the process Stating that you are doing research throughout the process Expressing that he/she applied the acquired knowledge by making a fruit cake Stating that she/he will create thought experiments with her/his students in her/his future professional life Finding useful/important what they learned in the process Stating that she/he will provide effective learning by using this experiment in her/his future professional life Appreciating what you learn in the process	"Thanks to the brainstorming we did in this week's lesson, I saw that I could reach more information when we examined this experiment in depth ."(#S3). "The experiment really got me thinking a lot because it was such that this experiment could be repeated with many variables, not just one." (#S1)
Attitude thoughts towards the lesson/experiment	Seeing the correctness of their hypotheses as a reward Seeing the lesson/experiment as fun Expressing that they have no difficulty in conducting experiments/research Finding it exciting to learn new things Describing the experiment as practical/easy Indicating that you like the problem scenario Finding it enjoyable to think about the experiment Indicating high-class participation	"It was good in terms of value because there was information that would be useful in our daily lives. I had no difficulty doing the experiments". (#S2) "I had no difficulties in this week's experiment; it was an easy and practical experiment." (#S6)

Thoughts on the method used	Understanding the relationship between experiment and hypothesis through the method used Thought experiments enable learning The idea that the method used facilitates the acquisition of knowledge Providing an in-depth review of the experiment Understanding the relationship between variables and hypothesis End-of-course discussions eliminating misconceptions about concepts Preparing a concept map encourages research	"I realized that I needed to design an experiment by my hypothesis with the method used. And while experimenting, I experimented wrongly that I had to choose my dependent and independent variables according to my hypothesis. I eliminated this problem by changing my hypothesis." (# S5)
Thoughts of associating with daily life	Inferencing that the cut fruits should not be left open Expressing that when you make a banana cake, you will drip honey on it to prevent browning Specifying that you will apply lemon on the fruits to slow down their darkening Noting that enzymes are present in many places in your daily life The statement that the experiment left a mark on his/her life Stating that she/he can use the knowledge she/he has learned throughout her/his life Indicating that you will put it in lemon juice to prevent the fruits from darkening	"We can apply lemon to prevent the fruits from darkening. We do this to prevent the enzyme from encountering oxygen. I can apply all this learning in my daily life." (#S4) "In terms of the mark it left on my life, I had the opportunity to observe the effect of cold on enzyme work." (# S2)

Analyzing the students' science journals, they were categorized as thoughts on gaining knowledge, thoughts on the learning process, thoughts on attitude towards the lesson/experiment, thoughts on the method used, and thoughts on associating with daily life. In the theme of thoughts on knowledge acquisition, the students' science journals include their thoughts on what they learned and understood and the enzyme-chemical reaction relationship. The students said they found what they learned during this activity valuable and important. They would like to use these and similar activities in their lessons in their future professional life. The student's thoughts about the learning process reflected in their science journals on this subject were included in the theme. At the same time, the students wrote sentences in their science journals indicating positive attitudes towards the science laboratory lesson where this activity was carried out and the experiments. They said they had fun, were not forced, and found it enjoyable. The diary entries were grouped as attitude thoughts towards the lesson/experiment. Another focus point mainly expressed in science journals is the hypothetico-deductive reasoning cycle based on the activities and scientific research steps, such as determining variables, forming hypotheses during the cycle's operation, and elements such as class discussions and concept maps. In this direction, the students' writings were thematized as thoughts on the method used. The last theme in evaluating students' science journals is their thoughts on associating with daily life. In their science journals, the students expressed their thoughts on how they would carry their gains from the activity into their lives and presented examples that we understand to create awareness.

The information showing the pre-experiment, post-experiment, and total scores because of the evaluation of the students' concept maps with rubrics is presented in Figure 4.

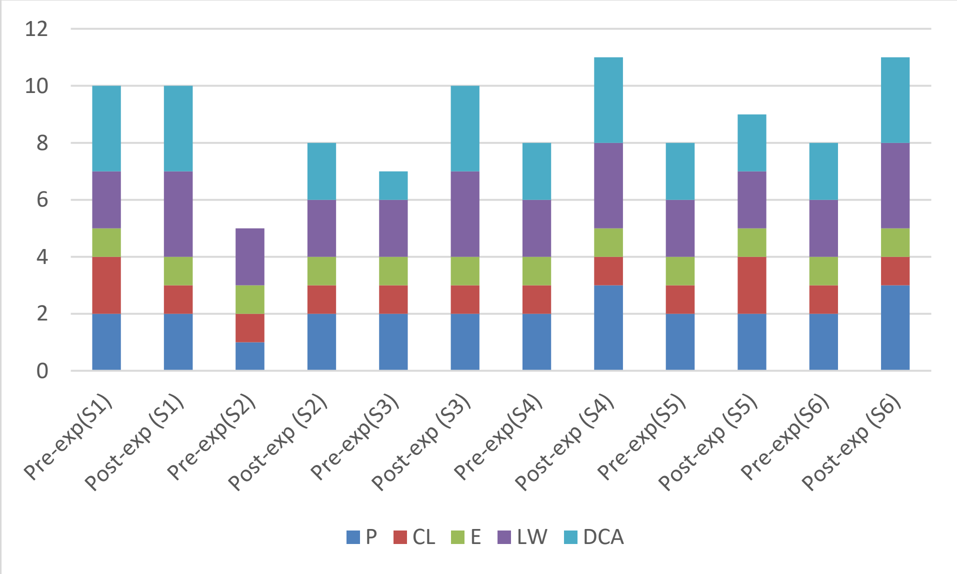

Figure 4. *Rubric evaluation results of students' concept maps*

As seen in Figure 5, the level of association in the students' concept maps increased compared to the pre-experiment. This shows that students' conceptual gains about enzymes have increased. When examined in more detail, it was understood that the students considered enzymes as one of the organic substances that catalyze the biochemical reaction in their concept maps. They made conceptual associations by emphasizing the factors affecting the work of enzymes. Among these factors, conceptual links have been established, especially on the effects of inhibitor and activator, pH value, temperature, amount of water, and the cause-and-effect component between enzymes. Students' concept maps reveal they have established correct connections between chemical and enzyme reactions. The students reflected on the inference that the color change in fruits could occur due to the reaction of the polyphenol oxidase enzyme with the oxygen and tannin chemicals in the form of propositions on their concept maps.

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

In the 21st century, we all need to be lifelong learners (Laal & Salamati, 2012). Higher education policy documents worldwide are increasingly using lifelong learning as a philosophical and conceptual framework to define the role of education in narratives of global and national transformation (Walters & Watters, 2001). Teachers, trainers, researchers, and all employees in the education and training industry have a high priority in providing lifelong learning opportunities (Chapman et al., 2005). Pre-service teachers who will form future teachers are also included in this priority group, and learning opportunities that support lifelong learning should be offered to them. A variety of learning opportunities characterizes lifelong learning, and these opportunities are shaped by the needs and contexts defined by the learner (Friesen & Anderson, 2004). According to Tatık and Ayçiçek (2022), lifelong learning should be adopted as a principle to train individuals who can meet today's needs, who develop themselves, who know how to access information, who use the information, and who are open to development. For this reason, activities and opportunities should be carried out to increase the lifelong learning competencies of teacher candidates. In this context, it is aimed at supporting lifelong learning through research and context-based activities associated with daily life.

Enzymes are found in almost every aspect of life today. Enzymes are used in many areas, from textiles to food processing or pharmacy, to diagnose and treat various diseases. These biomolecules are utilized in effective and eco-friendly manufacturing processes, particularly in the industrial sector. Enzymes are used daily as one of the methods of making the recycling processes of artificially produced polymers, which we generally know as plastic, efficient and biodegradable (Sarıgul, 2018). Hence, comprehending enzymes, which play a significant role in our everyday lives, is a crucial matter concerning both specialized educational resources and fostering scientific awareness and lifelong learning. In this study, an inquiry and context-based activity were designed to model the factors affecting the work of enzymes, which are organic substances that catalyze many biochemical reactions. The design of the activity was based on a guided inquiry learning approach in which daily life contexts and hypothetico-deductive reasoning were used. In this activity, many causal and correlational relationships that may affect the work of enzymes were analyzed. In this way, it has contributed to understanding the problems encountered in daily life and the solution process. In this context, pre-service teachers' perspectives on lifelong learning would be thought to deepen.

In the study, data obtained from pre- and post-experiment reports, science journals, and concept maps prepared before and after the experiment were analyzed in order to evaluate student performances. In this context, firstly, the pre-and post-experiment reports were evaluated with the activity scoring guide, which was created in parallel with the planning and management steps of the scientific research. It was observed that most of the students designed scientific research and tested their hypotheses consistently and accurately. This result of the study is thought to affect the method applied. According to the results of the study by Tatık and Ayçiçek (2022), in which they investigated the program proposals of teacher candidates for lifelong learning, some of the personal qualities of students with lifelong learning skills are the ability to participate in learning, organize, and conduct research actively. Here, the outputs of inquiry and context-based learning activities, in which independent ideas are developed to provide knowledge and skills, intersect with the point of using the learning ability gained through inquiry for lifelong learning. Findings from student science journals support this prediction. Studies based on context-based learning and guided inquiry approaches revealed the positive effects of interventions on students' scientific inquiry and scientific process skills (Af'idayan et al., 2018; Koksal & Berberoglu, 2014; Ngozi, 2021). Unlike other studies, this study operated the activity through a hypothetico-deductive reasoning cycle. It is thought that this cycle (Lawson, 1995, p. 115), which is recommended to be used in lessons by Lawson, contributes to understanding the subject by providing a clear visualization of the process steps and a summary of the process. It is seen that this contribution of the hypothetico-deductive reasoning cycle is emphasized in the student science journals. One of the most striking findings in the data obtained from the student science journals is the positive attitude of the students towards the lesson and experiment. Students stated that they found the experiment enjoyable and exciting because they learned new things. This shows that the activity has a positive impact on student attitudes and motivations. Comparable results are seen in studies based on context-based learning and guided inquiry approaches (Kaya & Gul, 2021; Misbah et al., 2018; Parchmann et al., 2006).

According to the results of this study, only one of the students took part in Level III according to the activity scoring guide in inquiry and context-based practices; that is, they tested their hypotheses by designing scientific research, but it was determined that there were deficiencies in some steps of the experimental design. Other students took place in Level IV. In other words, students designed scientific research and tested their hypotheses consistently and accurately. At the beginning of the sections in which the students got the best scores from the rubric, the "association with daily life" section comes first. It is thought that this is related to the fact that the activity is a situation they encounter daily and the operation of the context-based inquiry process by giving them a problem scenario. It is stated that giving the students scenarios containing the problems they may encounter daily will effectively solve them by concretizing them, which is important in structuring knowledge and providing permanent learning (Celiker et al., 2014). Considering the context-based nature of the inquiry, the laboratory activity based on a guided inquiry learning approach using the hypothetical-deductive reasoning cycle produced significant outputs. In such a learning process, students gain experience by forming their hypotheses and planning the research process. At this point, they developed independent ideas under the guidance of teachers and gained self-confidence with their research. They took responsibility by gaining control over their learning through these experiences. Pre-service teachers can use the learning abilities they have gained in this way for lifelong learning. Carr et al. (2018) say formal, non-formal, and informal education should be integrated with lifelong learning by blending pedagogy and andragogy.

Students presented examples that relate the experiment's results to daily life and designed thought experiments based on these examples. As a result, the students carried out scientific research steps and exemplified what they learned by associating them with certain contexts. According to Herranen et al. (2019), inquiry-based teaching is not just following certain steps or doing research. It is also to explain, discuss, or defend the research results and relate them to the world around us. In this process, pre-service teachers are provided with daily life through questioning and reflection. Reflective practices in teacher education are essential in their contribution to developing critical inquiry skills and supporting lifelong learning. Such activities, which enable the development of teacher education practice and create opportunities for reflection, should be included in teacher education programs within the scope of lifelong learning (Dolan, 2012).

As a result of the analysis of the concept maps, it is seen that with the applied context-based activity, the students consider enzymes as one of the organic substances that catalyze the biochemical reaction, and they make conceptual associations by emphasizing the factors that affect the work of enzymes. At the same time, it is seen that students make the correct connections between chemical reactions and enzyme reactions. This study's result matches the relevant literature (Ceran-Aydin & Ates, 2019). The development of students' conceptual associations can be attributed to the activity-based teaching process. Similarly, Zhang (2018) stated that activities increase student learning and deeper and more permanent learning is achieved; Klahr et al. (2007), on the other hand, state that hands-on activities enrich students' knowledge by presenting the details of concepts, facts, and events thanks to one-to-one experiences; and Avinal (2019) states that students have the opportunity to better and more deeply understand the subjects as a result of the activities carried out in teaching practices. Students' progress at the conceptual level can be explained by their ability to model the factors that affect the functioning of enzymes. Students proved these models with thought experiments at the end of the research steps. In the thought experiments, students were asked to create a problem scenario using the information they learned and to design a thought experiment to solve the problem in this scenario. In the experiments, the hypothetico-deductive reasoning cycle was used. According to Lawson (2003), "If you do not reason hypothetically-deductively, you will not know what you have 'discovered," even if you have 'discovered' it!". As a result, this process shows that students discover the meanings of the concepts. This shows that the application contributes to the in-depth learning of the subject by applying the information learned by the students to a completely different context.

In the study, pre-service teachers revealed that they would like to use the gains they obtained from the inquiry and context-based practice activities in their classrooms when they become teachers. Regarding this, the students stated in their science journals that they wanted to do experiments like the enzymatic browning experiment with their students in their future careers; they thought that such experiments would provide effective learning, and they wanted to use thought experiments and found what they learned valuable. This is also an indication of their self-confidence. Breslin (2016) says that learning is for life within the scope of lifelong learning, and we should build the capacity and confidence of each student to continue learning autonomously and creatively. These thoughts also relate to students' professional beliefs, attitudes, and values. In this context, in this study, an evaluation of the attainment levels of these variables was not made. It is predicted that this situation, which can be expressed as one of the limitations of the research, can be realized with long-term and multidisciplinary collaborative studies. In this context, it can be said that more research is needed through professional development programs that can shed light on the subject.

The scope of teacher education programs can be a precursor for teacher candidates to gain motivation and perspective on lifelong learning. Dolan (2012) states that skills such as questioning, analyzing, researching, critical thinking, problem-solving, communicating with others, and learning using information and communication technologies are lifelong learning skills. In this context, it can be suggested to expand the use of inquiry and context-based activities in this study in teacher education to support lifelong learning. In addition, it was concluded that science journals are highly effective in obtaining the output of inquiry and context-based reflective practices compatible with teacher education pedagogy. For this reason, it is recommended to use science journals, which are effective reflective individual products and can give direct information about life, to see the results of purposeful learning activities carried out to develop knowledge, skills, and competence, which are also included in the definition of lifelong learning.

Due to the pandemic, group work could not be done in this activity, as it was done remotely through the Microsoft Teams Program. Although classroom discussions were held within the scope of the activity, it is considered important to repeat a similar practice in group work, considering that cooperative learning skills are one of the lifelong learning skills and the positive results of in-group discussions and cooperative work on learning outcomes.

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