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Pre-Service Teacher Scientific Behavior: Comparative Study of Paired Science Project Assignments

Mizrap BULUNUZ *
Menekse Seden TAPAN BROUTIN **
Nermin BULUNUZ ***

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Abstract

Problem Statement: University students usually lack the skills to rigorously define a multi-dimensional real-life problem and its limitations in an explicit, clear and testable way, which prevents them from forming a reliable method, obtaining relevant results and making balanced judgments to solve a problem.

Purpose of the Study: The study examines the processes undergone by students in two projects and the results of these projects. One of the projects was on the subject of heat waste in the buildings of a university's school of education. The other project was a new version of that project conducted by a group of students in the following year.

Method: The study was conducted with eight pre-service science teachers who were third-year students in the Science Teaching and Laboratory Practices course at a state university's education school located in Turkey's Marmara Region. Case study, a qualitative research method, is used to obtain detailed and in-depth information. The research data for this report were obtained from the students' project posters, interviews with the instructor and semi-structured interview records of interviews with the students.

Findings: In the first project, pre-service teachers had serious difficulty identifying a testable research problem they encountered every day as well as developing a method to solve such a problem. Therefore, the

* Corresponding author: Dr. Uludag University, Faculty of Education, mbulunuz@gmail.com
** Dr. Uludag University, Faculty of Education, tapan@uludag.edu.tr
*** Dr. Uludag University, Faculty of Education, nermin.bulunuz@gmail.com

collected data could not be analyzed because of the complexity of the data, the failure to adjust the plan to reality and the abundance of variables. Pre-service teachers in the second project began by determining an explicit, clear and testable research problem, including dependent and independent variables, regarding the waste of heat in university buildings. Two factors were very influential for this project's success. First, re-evaluating a previous research problem was more advantageous than determining a research problem from scratch, which can be explained by the fact that science is a process that progresses cyclically and cumulatively. Second, there was more intense dialogue and cooperation between the instructor and the students in the second project than in the first project.

Conclusion and Recommendations: The present study revealed that when linear scientific research project practices are replaced with cyclical scientific research processes, new and more advanced projects with a wider sphere of influence can be achieved. Providing pre-service teachers with scientific research opportunities is a way to help spread the attitudes and skills needed for research, development and innovative thinking more widely throughout society.

Keywords: Scientific research, project-based learning, research and development, innovation, teacher training

Introduction

Project-based learning is based upon the ideas of John Dewey, Jean Piaget and Lev Vygotsky, constructivist learning theorists. According to Dewey (1996/1916), there are no true educational goals in situations where the teacher determines the student's every act and the student only follows the lesson and does the work provided by the teacher. Educational goals exist only when the pieces of knowledge being taught are coherent and separate activities follow one another. To Dewey, the primary feature of a good educational goal is that it arises from existing conditions; its value depends on its rearrangement of such conditions. Thus, Dewey emphasized that educational activities must be cyclical and coherent, because every process leads to another activity in real life. In brief, Dewey's ideas have greatly shaped project activities at schools. Piaget (1973) stressed that students should be nurtured as creative individuals capable of discovering and inventing new things rather than merely repeating what previous generations did. To this end, they should not be passive collectors of knowledge taught at school: rather, they should question and check whether the knowledge provided to them is true and think critically (Piaget, 1973). The project tasks reported in this paper were cooperatively performed by students and teachers on the bases of personal contribution and participation. Therefore, these tasks are associated with Vygotsky's social learning theory and scaffolding in learning (Stenhouse et al., 2014).

In *Service of Learning and Empowerment*, Stenhouse et al. (2014) indicate that problem-solving projects depend on service learning and critical pedagogy in addition to constructivism. Service learning is defined as "pedagogical practice that integrates service and academic learning to promote increased understanding of course content while helping students develop knowledge, skills, and cognitive capacities to deal effectively with the complex social issues and problems" (Hurd, 2006, p.1). Service learning, which is project-based and requires students' active participation, depends on students' knowledge and experiences and the society in which they live. According to Hurd (2006), exposing students to real-life issues and problems not only improves their decision-making and problem-solving skills in social issues but also helps them develop strategies for adapting knowledge to new conditions. Problem-solving projects must be carried out collectively by students, their instructors, their peers and other stakeholders at the university in order to fully develop the abovementioned knowledge and skills. Unfortunately, today, most students enter and graduate from university without critical-thinking or problem-solving skills (King, 1992). For instance, Bulunuz (2011) found that Turkish pre-service science teachers have low levels of participation in scientific research projects at the university level and primary and secondary schools and that the quality of their project experiences is quite poor. Problem-solving skills include a wide variety of knowledge and skills, such as gaining awareness of the problem and determining its exact scope and limitations. Real-life problems are usually open-ended, multi-dimensional and complex. The fact that most university students lack the skills to rigorously define a multi-dimensional real-life problem and its limitations in an explicit, clear and testable way prevents them from forming a reliable method, obtaining relevant results and making balanced judgments to solve a problem (Hurd, 2006). Problem-solving projects improve students' knowledge, skills and reasoning and decision-making abilities. Previous research reveals that service learning: 1) enhances students' skill to apply the knowledge they acquire in a project to new situations and real-life problems (Rasmussen & Skinner 1997; William, Youngflesh & Bagg, 1997; Eyler & Giles, 1999; Markus, Howard & King, 1993), 2) provides them with the ability to thoroughly understand the causes of complex problems and find solutions to them (Eyler & Giles, 2002; Barron et al. 1998; Bransford & Vye, 1989; Bransford & Schwartz, 2000; Mabry, 1998) has a positive effect on their ability to define complex problems, take practical actions to solve them and think critically (Batchelder & Root, 1994; Bhaerman et al. 1998; Boss, 1994; Eyler & Halteman, 1981).

In problem-solving projects, teaching is predominantly based upon critical pedagogy and challenges traditional educational approaches. The latter stresses a teacher's role in the learning process, limits students' learning environment, largely maintains pressure and dominance and results in a one-way knowledge transfer. In contrast, problem-solving teaching supports a dialogue-based teaching process in which teachers and students seek to acquire, organize and apply knowledge together (Stenhouse et al., 2014; Shor, 1992). The foundation of critical pedagogy is the integration of thought and action (Freire, 1991; Aronowitz & Giroux, 1991; Spring, 1997). Freire's (1991) problem-posing education approach views the world not as knowledge to be learned but as a question to be examined, interpreted and discussed. Problem-posing education is a creative approach that includes decoding reality and intervening in it critically, revealing students' consciousness, encouraging focused thinking and practicing taking action based on reality. Such an approach is based on joint discussion and reasoning on the same topic by teachers and students in dialogue and cooperation (Freire, 1991).

Traditional pedagogy does not allow students to question the world in which they live or the knowledge presented to them as reality, nor does it develop their critical thinking skills (Freire, 1991; Yilmaz & Altinkurt, 2011). According to Giroux (2009), critical pedagogy aims to use educational practices and schools to create an environment where teachers and students can effectively question and discuss the relationships between theory and practice, between critical analysis and common sense and between learning and social transformation. The goal of critical pedagogy is to create improved environments for life and learning through individual and collective thoughts and actions (Stenhouse et al., 2014). Critical pedagogy practices include student engagement in processes such as observation, definition, examination, search and reflection. The change produced by students' willingness to participate in these types of educational processes in their thoughts, attitudes and intentions challenges the status quo (Stenhouse et al., 2014). According to Giroux (2007), knowledge and the status quo are always questionable, discussible, accountable and re-approachable in the context of critical pedagogy. Thus, research should be conducted that questions rather than legitimizes the status quo. University students should receive an education that provides them with critical thinking habits and a passion for social responsibility rather than an unthinking general education, at least at higher education levels (Giroux, 2007). All in all, problem-solving projects support many principles of critical pedagogy, among them improving students' critical thinking capacities and enabling them to consider transforming their existing conditions to better ones, to take actions accordingly and to put the knowledge they acquire into practice in different fields.

Problem-based education is a student-centered pedagogy in which students learn about a subject through the experience of problem solving. Problem-based education is a flexible way of learning in which students take responsibility for their own learning (Semerci, 2005). Therefore, in education, students must be confronted with situations that can be encountered in real life. The first mission of a school must be, beyond any knowledge transfer, to provide students with the knowledge and skills required for solving the types of problems experienced in real life outside school by providing them with pertinent experiences. Only this type of education will contribute to students' real lives by allowing them to adapt to real life outside the school. For that reason, lessons provided at school should be adapted based on students' interests and attention (Timmins & Bryant, 1999). When pre-service teachers start to serve at schools, they may encounter many problems that prevent their students from learning. If these problems are not solved, teachers cannot provide effective teaching, and students cannot experience their highest possible level of academic success (Semerci, 2005:2006). Thus, teachers' acquisition of the knowledge and skills to scientifically address a problem that they might encounter in real life and to find a solution to such a problem is quite important for their professional success. For instance, Butun and Sen (2001), who conducted a study on pre-service computer teachers, found that pre-service teachers are happy working together in problem-based teaching; they produce more solutions to problems, and they use resources more efficiently than otherwise. The project-based learning approach, which is frequently employed in foreign teacher training programs, both contributes to good teacher training and improves their motivation to teach well (Dean, 1998; Helle, Tynjala & Olkinuora, 2006).

Scientific research projects are carried out at primary and secondary schools every year through the allocation of a large amount of resources and time both in Turkey and worldwide. For example, the Scientific and Technological Research Council of Turkey (TUBITAK) organizes annual regional and national competitions in the fields of science and technology, mathematics and social studies for primary and secondary education students. The expectation is that participation in these project competitions provides students with a learning experience where research, questioning, imagination and creativity are featured, distinct from rote learning based on textbooks. However, counseling teachers, who take part in these competitions with their students, have difficulty finding project topics that have not been used before and turn to various faculty members for help on this subject. The research project competition guidebook includes the expression "no form and method employed before" and thus implies that no project carried out in the past may be repeated identically (MEB, 2013). As a result, teachers desperately search for projects that are not included in the project bank because the guidebook is not examined carefully for slightly different options, and they act based on what they hear. Any announcement by school administrators about participation in project competitions using the words "an authentic project that has not been conducted before" may produce a misperception among teachers. This rigid wording suggests that administrators and teachers who prepare their students for project competitions have misconceptions or imperfect knowledge about the nature and functioning of science itself. Conducting a "unique and unprecedented" research project is very hard and against the nature of science itself (Dogan, Cakiroglu, Bilican & Cavus, 2009). Isaac Newton, the famous scientist, inventor and philosopher, famously said, "If I have seen further than others, it is by standing upon the shoulders of giants." The careful replication of experiments is an important endeavor in science to validate, reject or refine previous research by others. Thus, it would be a proper start to examine previous project topics, to review projects on the subject one is interested in and to make use of the experiences, knowledge, and implications provided in previous projects.

Scientific knowledge is primarily produced and developed in a linked and cumulative way (Topdemir & Unat, 2012). This is because science is not a linear process, such as "problem→experiment→result". On the contrary, it is a cumulative process that starts at one point and proceeds by expanding in a spiral (Victor & Kellough, 1997). Models of linear and cyclic scientific approaches are provided in Figures 1 and 2.

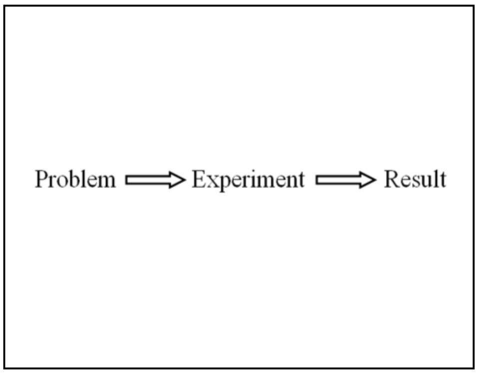


Figure 1. *Linear scientific research model*

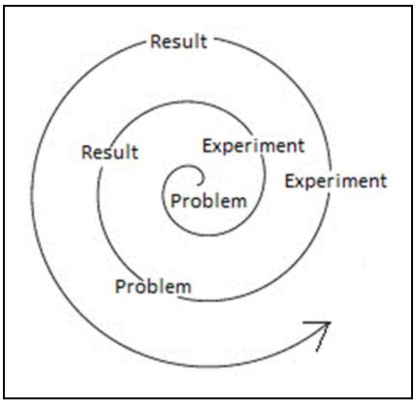


Figure 2. *Cyclic scientific research model*

Our observations and experiences of the TUBITAK project competitions demonstrate that projects submitted in primary and secondary competitions are usually one-time experiences and fall outside students' normal experiences and areas of interest and above their ability levels. That goes against the fundamental underlying principle of these competitions: Ideas that are the subjects of research shall include the interests and experiences of students, and students should make mental contributions to research (TUBITAK, 2010). Hawking (1990) defines such situations in education as a vicious cycle: Some students who have never undergone scientific training or engaged in a quality scientific research project experience become teachers. Subsequently, these teachers then provide a new generation of students with poor project experiences (Bulunuz, 2011). To end this vicious cycle, pre-service teachers should therefore receive teacher training programs that provide project experiences with research and development and innovation ideas. According to the literature review conducted in the present study, there is no case study that addresses project practices focusing on research and development and innovation ideas in educational institutions. Most studies are statistical ones that focus on pre-service teachers' academic achievement, conceptual development (Tasoglu & Bakac, 2010), critical thinking skills (Semerci, 2006) and motivation (Tosun & Taskesengil, 2012). The present study introduces and evaluates a research and innovation-based learning and teaching approach. The study examines the processes undergone by students in two projects and the results of these projects. One of the projects was on the subject of heat waste in the buildings of a university's school of education. The other project was a new version of that project conducted by a group of students in the following year. The research questions were:

1. In what scientific processes did pre-service teachers participate, and what results did they obtain in the first heat waste project?
2. In what scientific processes did pre-service teachers participate, and what results did they obtain in the second heat waste project?

Method

Research Design

This study introduces and evaluates two real-life projects that built on one another. The first project was on heat waste in the buildings of an education school. The second project was a new version of the previous heat project conducted the following year by another group of students. A qualitative research method was used to examine students' project-creating processes and to closely monitor, thoroughly describe and effectively interpret the studied case's events and phenomena (Yildirim & Simsek, 2004). This is a case study that includes an in-depth examination of interrelated projects on heat waste in buildings through methods and techniques such as interviews, observations and document analyses. Case study, a qualitative research method, is used to obtain detailed and in-depth information on one or several cases (Creswell, 2007). According to Yin (2003), case study involves empirical analysis, with multiple data sources on a current case in its natural environment. Yin (2003) differentiates four types of case studies: holistic single case study, embedded single case study, holistic multiple case study and embedded multiple case study. In this research, holistic multiple case study design was adopted. This model dwells on several holistic cases, and every case is treated as one in itself. Then comparisons are made, and the similarities and the differences between the cases are brought out for explanation (Baxter & Jack, 2008; Creswell, 2007; Yildirim & Simsek, 2004; Yin, 2003). Data related to the two projects on heat waste in the buildings were collected systematically, and an attempt to determine the relationships between the variables was made.

Study Group

The study was conducted with pre-service science teachers who were third-year students in the Science Teaching and Laboratory Practices course at a state university's education school, located in Turkey's Marmara Region. The study was conducted in the spring semesters of two successive academic years. All students who took that 40-student course over those two spring semesters were divided into groups of four or five and conducted scientific research projects. Eight students (two project groups) studied the heat control in the buildings in total (i.e., four people each semester). These two projects were chosen for examination after evaluating them in terms of their appropriateness to the problem statement. They were also selected because they employed cyclic processes and thus were examples of scientific research processes. Class participation and grade point average were moderate among the pre-service teachers. In addition, these teachers had generally had quite poor project experiences previously (Bulunuz, 2011).

Data Collection Tools and Their Application

The pre-service teachers were asked to develop a scientific research project on a subject that aroused their interest or curiosity within the scope of the Science Teaching and Laboratory Practices course. They were told that their project had to have a logical framework that contributed to science, detect a problem encountered in real life, and generate a solution to that problem. Before starting, the course instructor provided information about the project's nature and how it was to be conducted, brought project samples from previous years to the classroom and asked the students to examine and criticize them. The pre-service teachers were told they could either select a new topic or conduct a project that readdressed and improved any of the projects they had reviewed.

The research data for this report were obtained from the students' project posters (see Appendices 1 and 2), interviews with the instructor and semi-structured interview records of interviews with the students. The interview records were subsequently transcribed. Data triangulation was performed to ensure the study's validity and reliability. Within this scope, the instructor provided opinions regarding the interview record samples, project poster photos and project analyses.

A faculty member who specialized in science analyzed the research data independently of the researcher's analysis. Among the researchers who made analyses, the one specializing in science was actively involved in data collection. The second researcher who made analyses obtained documents and recordings once the data collection ended. She also conducted an interview with the teacher to better understand the missing elements in the data obtained, which would serve to interpret the findings. Yet another faculty member, specializing in qualitative research methods, checked these two analyses. These cross-checks ensured that the researchers' results were consistent and suitable for qualitative analysis techniques.

Data Analysis

The research data were analyzed based on the themes created by the researchers. The first project's deficiencies were analyzed in terms of various variables, and how these variables were handled in the improved project was examined in terms of improvements and their appropriateness to the nature of science. Based on TUBITAK (2014) project evaluation criteria, the following themes were used to analyze projects: a) a clear statement of the problem, b) the project's viability with the problem situation provided, c) the project's significance and necessity, d) an explicit and clear description of the data collection methods, e) an effective interpretation of the collected data that clarifies the problem situation and f) an explanation of the project's sphere of influence.

Results

This study examined the process by which a group of pre-service teachers created a project on heat control in a university's education school and the process by which another group of pre-service teachers repeated and improved that project. The analyses of the two student projects are presented under two titles (the first project and the second project) within the framework of themes derived from TUBITAK's project evaluation criteria (2014).

Scientific Processes Conducted and Results Obtained in the First Heat Waste Project by the Pre-Service Teachers

The first project failed to define a problem. Instead, the project purpose was stated as "determining the temperature differences between the floors and rooms in the school of education block A and investigating the causes of these differences, if any". To this end, the students measured and recorded the temperatures of rooms on every floor of the education school with thermometers. Appendix 3 presents the data table related to the temperature values they obtained. However, the students were unable to analyze or interpret these data to identify a problem situation. They found differences but failed to tie the differences to a problem to solve. The most important reason was that they failed to determine a testable research problem explicitly and clearly. Thus, a great majority of the data was obtained without controlling the variables (e.g., whether the classroom was full or empty or the number and length of radiators in classrooms). Thus, the pre-service teachers were unable to interpret or draw conclusions from their data from a scientific point of a view—data they had collected in such a complex manner. Nevertheless, the pre-service teachers completed their project by suggesting that an air curtain be installed in the school's main entrance, which is always open; providing general information, such as the cost of wasting heat; noting the benefits of heat loss control; and proposing actions to control heat loss. In brief, they failed to establish a link between their stated project purpose and the results they obtained. The results were potentially useful but failed to meet the scientific rigor test.

The interview conducted with the pre-service teachers who conducted the first year's project revealed that they were able to evaluate deficiencies in the project. The analyses of interview transcriptions demonstrated that the pre-service teachers needed the assistance and guidance of the instructor most of all when determining the project topic. The dialogue below consists of the statements in which pre-service teachers expressed the points in the project process when they had the most difficulty.

> ***Instructor:*** *…During which stage of this project did you experience the greatest difficulty?*
>
> ***Pre-service teacher:*** *In determining the project topic. Deciding on the project topic was a difficult stage for me.*
>
> ***[…]***
>
> ***Instructor:*** *...If you make your students conduct a project in the future, in which stage do you think they will need your support?*
>
> ***Pre-service teacher:*** *I needed help most in determining the project topic. In other words, we did not know what to work on. That is, what project to conduct … It may be something interesting to the students, or we may offer the topic.*
>
> ***Instructor:*** *I already set you free to work on something interesting to you …*

Pre-service teacher: *You set us free. It is better if the project is about something interesting to us. Indeed, if we set students free to select any topic interesting to them, they can go and select topics suitable for themselves. You set us free, but we failed to decide.*

As is clear from the dialogue above, the pre-service teachers had the greatest difficulty determining their project topic. This is because the expectation that their project have a logical framework that contributed to science, detect a problem encountered in real life and generate a solution to such a problem forced them to think "outside of the box." The interview analyses revealed that the pre-service teachers experienced intellectual processes similar to those experienced by scientists when conducting scientific research, including deciding upon a topic with relevance to reality.

In addition, pre-service teachers thought that the largest deficiency in their final product was their failure to bring together and interpret data in a way that allowed them to clarify the problem situation. A dialogue between a pre-service teacher and the instructor concerning this finding is given below.

Pre-service teacher: *The biggest deficiency in our project was our failure to make comparisons. For example, the other building is hotter because its door is double-glazed.*

Instructor: *Really?*

Pre-service teacher: *You said that we could measure. We really went and measured. It was hotter.*

Instructor: *Wow! I did not know that.*

Pre-service teacher: *It is hotter, but here it's colder. We did not compare them. For example, two doors of this building are open, but two doors of the other building are not open. They are always closed. It is hotter. The first entrance is colder in ours. Indeed, we could have added that to our project.*

As revealed in the quotation above, the instructor communicated with the project team, monitored their project and expressed opinions that drove them to think. In addition, it is evident that the students on the project team made various unplanned observations and tests on their topic but failed to put the ideas gained through observations into action. The pre-service teachers did not include their suggestions to improve the project, which they put forward in their interviews and project poster. However, these unexpected discoveries and suggestions are among the most important elements of the scientific research process, which progresses by expanding in a spiral cycle.

Scientific Processes Conducted and Results Obtained in the Second Waste of Heat Project by the Pre-Service Teachers

Pre-service teachers in the second year's project group aimed to improve the project described above by redesigning it, first seeking reasons for the original project's non-completion under the instructor's guidance and second expressing the research problem and sub-problems in more testable ways. The research problem was amended as follows: "Is there any temperature difference between block A and B of the school of education?" The pre-service teachers observed that two university buildings had the same architecture, but the entrance door of one was broken and thus always open, while the entrance door of the other building was hydraulic and closed when not used. The project poster included photos related to these observations (Figures 3 and 4).

Figure 3. *Entrance door of block A*

Figure 4. *Entrance door of block B*

Moreover, in contrast to the first project, the pre-service teachers who conducted the second project addressed the importance and necessity of heat control and energy savings from the scale to a single building to that of the world. The poster prepared for the second project demonstrates that these pre-service teachers built their project on knowledge, observations and experience. Within this scope, they indicated the significance and necessity of the research in three main findings: 1) There is a significant temperature difference between the two blocks; 2) the instructors in block A predominantly have electric heaters in their rooms; and 3) the door of block A is always open, unlike the door of block B.

The pre-service teachers collected both quantitative and qualitative data. Within the scope of quantitative data, the temperature was measured for five working days in blocks A and B. The fact that the pre-service teachers conducted temperature measurements by calibrating the thermometers used in the same time slots increased their research's validity and reliability. The thermometers (Durotherm) used in the project and the temperature data belonging to the blocks A and B are provided in Figure 5 and Figure 6, respectively. These students found a temperature difference of approximately 4 °C between the buildings.

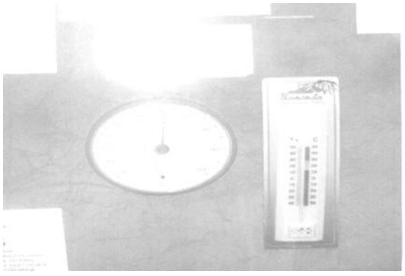


Figure 5. *Thermometers*

Days	Block A	Block B
Monday	7°C	11.5°C
Tuesday	8°C	12°C
Wednesday	7°C	11°C
Thursday	10°C	13°C
Friday	9°C	13.5°C
Average Diff.	4.0 C°	

Figure 6. *Temperature data from the second project in the blocks A and B*

Within the scope of the qualitative data, the students conducted interviews with 25 instructors from blocks A and B (block A: 10; block B: 15). Three of 15 instructors from block B and all the instructors from block A used electric heaters. The pre-service teachers also took photos of the instructors' rooms with electric heaters. They included some of these photos in their project poster. Figure 7 is a photo of an instructor's electric heater in block A.

Figure 7. *Room with an electric heater in it*

Block A instructors stated that they were often cold, although the radiator worked. The findings of the improved project were as follows: There is an average temperature difference of 4 C° between blocks A and B in the education school, two buildings that have similar architecture, and the largest reason for this difference is the open or closed states of the main entrance doors. The pre-service teachers recommended that the entrance door of block A be replaced by a photocell door for heat control and energy savings. Students shared their project findings and suggestions with the department head's and dean's offices. As a result, the entrance door of block A was modified to close automatically. Figure 8 shows block A's completely new photocell door system. This project in teaching research processes had the serendipitous result of also becoming a "service-learning project."

Figure 8. *New entrance door of block A*

The pre-service teachers stated in the poster prepared for this second project that the results of their project could have a national and global influence.

The instructor was asked to evaluate the guidance he provided for the two separate projects. The instructor's interview about the first project contains this statement:

> *"I failed to see that the research problem of the first heat waste project was not testable. The students went and collected data. Then, they brought the data to class as a project proposal. We noticed that no result could be obtained based on the collected data. We noticed it together. Those data generated no result … When I saw that they generated no result … I told the students that they could make a comparison with something different. I told them that they could go and examine the other block. They brought the same data to the end-of-period project exhibition without making any change in them … The project failed because of the students' laziness."*

As revealed by the quotation above, the instructor mentally switched from a problem statement to a project purpose and thought that the students could naturally do the same: Although the first project had no problem statement, the instructor commented on the problem statement based on the project purpose. However, the instructor said that the first project's problem about its purpose or research problem was noticed only when the pre-service teachers submitted the project proposal in the classroom. This late diagnosis and the ideas put forward to address it were not sufficient to eliminate the problem. This is because the pre-service teachers did not want to make irrelevant all the data they had collected and to begin to collect data again.

The instructor should have intervened before the pre-service teachers proceeded to the data collection stage. He did detect the problem in the project and tried to guide the students, even if it was late. However, the students did not collect data again because it was close to the end of the semester. In the interview, the instructor expressed the non-completion of the first project with the following words: "The project failed because of the students' laziness. We thought that a comparison could be made with the opposite building, but they brought the project to the project exhibition without doing so."

The instructor also spoke about the second project:

"A group of students said that they wanted to work on 'heat waste in university buildings', which was a project topic in previous years. I accepted it with pleasure. This is because I had already determined the project's deficiencies with the previous group. I asked the pre-service teachers to analyze the project and detect the problems. Then, I described our experiences in the first project to the pre-service teachers. My most important realization from the first project was that the research problem of a project must be testable. While I was guiding the second year students, I requested all groups to write their research problems, including dependent and independent variables, in an explicit and clear way. I repeated this request so frequently that it became a joke among the students: 'Well, but what is your research problem?' In other words, I realized that the success of research depends on the clarity of the research framework (i.e., the research problem). So I was very careful about that in the second year projects …Additionally, I asked the pre-service teachers to think about what other steps they could take to further improve that project. The pre-service teachers recommended conducting interviews with instructors from two buildings and making observations in their rooms. I liked that idea very much. I think it was the most important innovation this group brought to the project."

Whereas the instructor guided the first project on the basis of theory and ideas, he guided the second project by integrating theoretical knowledge with concrete project examples. The instructor had some general idea about conducting projects, but he lacked sufficient experience when guiding the first project. However, he was more experienced during the second project due to the analyses and evaluations made in the previous year. Thus, the instructor provided more effective guidance for the second project in comparison to the first one, particularly in determining the research problem. In addition, pre-service teachers working on the second project were more "experienced" than those who worked on the first project because they read prior work on the project topic. The former group had to conduct a project on heat control in university buildings from scratch. However, the second group started by analyzing the reasons why the first project was not completed. In other words, the second project's pre-service teachers were able to start by seeing what to avoid. Both the instructor and students learned these key points about the sometimes-messy scientific processes by doing actual, hands-on science research.

Discussion and Conclusion

The following results come from analysis of the two topics based on the selected themes: In the first project, pre-service teachers had serious difficulty identifying a testable research problem that they encountered every day as well as developing a method to solve such a problem. Therefore, the collected data could not be analyzed because of their complexity, the students' failure to adjust the plan to reality and the abundance of variables. That reveals that the biggest difficulty the students faced in the project process was using dialogue and cooperation to define the problem in a testable way and to determine the plan's limitations. According to Hurd (2006) and King (1992), the primary reason for such a result is that most university students are incapable of defining multi-dimensional real-life problems and their limitations in an explicit, clear, and testable way and formulating a set of meaningful hypotheses, reliable methods, coherent results and logical analyses to solve that problem. The inadequacy of the dialogue between the students and instructor on the subject of defining the problem as well as during the data collection stages contributed greatly to the project's failure. Another factor that influenced the first project's failure was that although the students noticed the project's weaknesses in their meetings with the instructor and made various observations to eliminate such weaknesses, they failed to take corrective action. This finding relates to the principle of integrity of thought and practice featured in critical pedagogy (Friere, 1991; Aronowitz & Girous, 1991).

The pre-service teachers who conducted the second project began by determining an explicit, clear and testable research problem, including dependent and independent variables, regarding heat waste in university buildings. Thus, a reliable method, results and sphere of influence could be designed for the problem's solution. Two factors were very influential on this project's success. First, re-evaluating a previous research problem provided more advantages than determining a research problem from scratch, which can be explained by the fact that science is a process that progresses cyclically and cumulatively (Dogan, Cakiroglu, Bilican & Cavus, 2009; Topdemir & Unat, 2012; Victor & Kellough, 1997). Second, more intense dialogue and cooperation between the instructor and the students took place during the second project than during the first project. Thanks to this dialogue and cooperation, the qualitative data obtained through the students' interviews with instructors about room temperatures and electric heater use increased the new research's validity and reliability when combined with the quantitative data comparing the temperatures of the two buildings. The second group's most important contribution to the research was that they revealed energy waste in the university building through comparative interviews in a very simple way. These findings exemplify the implementation of critical pedagogy, where teachers and students discuss and reason on the same topic in cooperative dialogue, decode and intervene in issues critically, think realistically and act based on reality (Freire, 1991; Giroux, 2009).

Both projects aimed to study an energy efficiency issue, possibly leading to a more physically comfortable environment in university buildings. The first project comprised research. The second comprised research coupled with technical development. In this regard, these two projects overlap in terms of the idea of creating improved environments for life and learning through thoughts and actions, which is the goal of critical pedagogy, and of challenging the status quo (Stenhouse et al, 2014; Giroux, 2007). The first project did not have a wide application because its collected data were not analyzed and the project was not concluded. However, the second project was viable, based on scientific data and possessed an explicit, clear and testable research problem. Thus, the second project could have a wider sphere of influence. That influence became concrete when the dean's office arranged to have block A's door replaced. This result exemplifies Dewey's (1996) idea that the primary feature of a good educational goal is that it arises from existing conditions and its value depends on its rearrangement of such conditions. Moreover, the finding that good science is educational parallels findings from previous studies on service learning: It improves the ability to apply knowledge to real-life problems (Rasmussen & Skinner, 1997; William, Youngflesh & Bagg, 1997; Eyler & Giles, 1999; Markus, Howard & King, 1993) and the ability to understand the causes of complex problems and subsequently take practical actions and think creatively to solve these problems (Bransford & Schwartz, 2000; Bhaerman et al., 1998; Boss, 1994; Eyler & Halteman, 1981; Eyler & Giles, 2002).

This case study demonstrated that if a failed scientific research project is not put aside and forgotten but examined and evaluated based on project evaluation criteria and then put into a cyclic scientific research process, a new and improved project might emerge. The project implementation processes and project results described in the present study comply with the goals and principles of TUBITAK's project competitions (TUBITAK, 2012: 2014). Thus, attempts may be made to generalize these types of practices because they allow pre-service teachers to use combined analytical and subjective experiences to learn the cyclic processes inherent to scientific research. Moreover, considering the cyclic nature of scientific projects, it becomes clear that one of the most important parts of a project is instructor suggestions—not directives. Suggestions guide people to "recycle" and continue a project, not to make the same mistakes again and to develop and explore new perspectives. Similarly, non-directive suggestions to the first student group might have led to a better outcome for their project without diminishing their need to stretch their intellects.

Suggestions

Based on the research findings, project-conducting training opportunities would likely be helpful for teachers and pre-service teachers to provide their primary and secondary education students with age-appropriate cyclic research process experiences. In addition, measures should be taken to ensure the proper use of project banks. These banks should not be seen as mere project debris but should function as guiding lights for future research. Every project included in project banks has the potential to enter the scientific research cycle. For that reason, in-service training that provide teachers with knowledge, skills and awareness about this subject should be provided to teachers at least, who are to take part in project competitions.

The literature on this subject needs to be enriched. A sample practice should be introduced to counseling teachers who are to take part in projects. The main purpose of project competitions to which large amounts of resources are allocated is to reveal and expand students' creativity by encouraging them to conduct scientific research. To achieve this purpose, pre-service teachers should gain higher quality research project experiences. That is the only way to generalize research and development and innovation ideas: by providing them to students via scientific research. Providing pre-service teachers with scientific research opportunities is a way to help spread the attitudes and skills required by research and development and innovative thinking more widely throughout society.

References

Aronowitz, S. & Grioux, H. A. (1991). *Postmodern Education. Politics, Culture, and Social Criticism*, University of Minnesota Press: Minneapolis.

Barron, B.J.S, Schwartz, D.L., Vye, N.J., Moore, A, Petrosino, A., Zech, L., Bransford, J.D. & the Cognition and Technology Group at Vanderbilt (1998). Doing with Understanding: Lesson from Research on Problem- and Project-based Learning. *The Journal of Learning Sciences*. 7(3&4), 271-311.

Batchelder, T.H., & Root, S. (1994). Effects of an undergraduate program to integrate academic learning and service: Cognitive, prosocial cognitive, and identity outcomes. *Journal of Adolescence,* 17, 341-356.

Bhaerman, Robert et al. (1998). *What are the purported benefits and results of service-learning, In The Role of Service-learning in Educational Reform.* NC: Simon and Schuster Custom Publishing, 37-49.

Boss, J.A. (1994). The Effect of Community Service Work on the Moral Development of College Ethnic Students. *Journal of Moral Education,* 23(2), 183-198.

Bransford, J.D. & Schwartz, D.L. (2000). Rethinking Transfer: A Simple Proposal with Multiple Implications. In A. Iran-Nejad and P.D. Pearson (Eds.), *Review of Research in Education,* 24, 61-101.

Bransford, J.D. & Vye, N.J. (1989). A Perspective on Cognitive Research and its Implications for Instruction. In L. Resnick and L.E. Klopfer (eds.), *Toward the Thinking Curriculum: Current Cognitive Research,* 173-205. Alexandria, VA: Association for Supervision and Curriculum Development.

Baxter, P. & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report,* 13 (4), 544-559.

Bulunuz, M. (2011). Fen Bilgisi Ogretmen Adaylarinin Gecmis Ogretim Kademelerindeki Bilimsel Arastirma Projesi Deneyimlerinin Degerlendirilmesi. *Turk Fen Egitimi Dergisi, 8(4)*, 74-85.

Butun, E. & Sen, M. (2001). Teknik Egitimde Problem Tabanli Ogrenme. Uluslararasi Egitim Teknolojileri Sempozyum ve Fuari Bildirileri, *Sakarya Universitesi Egitim Fakultesi Dergisi,*1, 128-132.

Chun, J. & S. Chon. (2004). Promoting student learning through a student-centered problem-based learning subject curriculum. *Innovations in Education and Teaching International,* 41(2), 157-168.

Creswell, J. W. (2007). *Qualitative inquiry & research design: choosing among five approaches.* London: Sage.

Dewey, J. (1996/1916). *Demokrasi ve egitim.* Ege Universitesi Yayinlari: Izmir.

Dean, C. (1998). PBL and Meeting the Challenges of Teacher Education. *PBL Insight, 1* (1) 9-10. In Billig, S. & Furco, A. *Service-Learning: The essence of the pedagogy.* Information Age Publishing, CT. 147-160.

Eyler, J. & Giles, D.E. (1999). Where's the learning in service-learning? San Francisco: Jossey-Bass Publishers. Eyler, J. and Halteman, B. (1981). *The Impact of a Legislative Internship on Students' Political Skill and Sophistication. Teaching Political Science, 9*, 27-34.

Eyler, J. & Giles, D.E.Jr. (2002) Beyond surveys: Using problem solving interviews to assess the impact of service-learning on understanding and critical thinking. In Billig, S. & Furco, A. *Service-Learning: The essence of the pedagogy. Information Age Publishing, CT*. 147-160.

Dogan, N., Cakiroglu, J., Bilican, K., & Cavus, (2009). *Bilimin dogasi ve tarihi.* Pegem Akademi: Ankara.

Freire, P. (1982). *Pedagogy of the oppressed.* The Continuum Publishing Corporation: New York.

Giroux, H. A. (2007). *Elestirel pedagoji ve neoliberalizm.* (Cev. B. Baysal). Istanbul: Kalkedon yayinlari.

Giroux, H. A. (2009). Dil/kulturel incelemeler alaninda elestirel pedagojinin bir rolu var midir? *Elestirel pedagoji soylesileri* (Cev. E. C. Babaoglu). Istanbul: Kalkedon Yayinlari.

Hawkins, D. (1990). Defining and bridging the gap. In E. Duckworth, J. Easley, D. Hawkins, & A. Henriques, *Science education: A minds-on approach for the elementary years,* 97-139. Hillsdale, NJ: Lawrence Erlbaum Associates.

Helle, L., Tynjala, P., & Olkinuora, E. (2006).Project-based learning in post-secondary education – theory, practice and rubber sling shots. *Higher Education,* 51, 287-314.

Hurd, C.A. (2006). *Is service-learning effective? A look at current research*. Retrieved from http://tilt.colostate.edu/sl/faculty/Is_Service-Learning_Effective.pdf

Kilinc, A. (2007). Probleme Dayali Ogrenme. *Kastamonu Egitim Dergisi,* 15 (2), 561-578.

King, P. (1992). How do we know? What do we believe?, *Liberal Education,* 78(1), 2-9.

Mabry, J.B. (1998). Pedagogical Variations in Service-Learning and Student Outcomes: How Time, Contact, and Reflection Matt er. *Michigan Journal of Community Service Learning, 5,* 32-47.

Markus, G., Howard, J., & King, D. (1993). Integrating Community Service and Classroom Instruction Enhances Learning: Results from an Experiment. *Educational Evaluation and Policy Analysis, 15(4),* 410-419.

Milli Egitim Bakanligi [MEB] (2013). *Bu Benim Eserim: Ilkogretim Ogrencilerine Yonelik IX. Matematik Ve Fen Bilimleri Proje Calismasi Uygulama Kilavuzu.* Online: http://tegm.meb.gov.tr/bubenimeserim/kilavuz.pdf.

Piaget, J. (1973). How a child's mind grows. In M. Miller (Ed.), *The neglected years*, 21-36. New York, NY: The United Nations Children's Fund (UNICEF).

Rasmussen, G., & Skinner, E. (1997). *Learning Communities: Getting Started* (ED433048).
Semerci, N. (2005). *Problem Temelli Ogrenme ve Ogretmen Yetistirme.* http://dhgm.meb.gov.tr/yayimlar/dergiler/Milli_Egitim_Dergisi/166/orta3-semerci.htm. Erisim zamani: 10/06/2014

Semerci, N. (2006). The effect of problem-based learning on the critical thinking of students in the intellectual and ethical development unit, *Social Behavior & Personality: An International Journal,* 34(9), 1127-1136.

Stenhouse, V.L, Jarrett, O.S., Fernandes-Williams, R.M., & Chilungu, E.N. (2014). *In the service of learning and empowerment service-learning, critical pedagogy, and the problem-solution project.* Charlotte, NC: Information Age Publishing, INC.

Shor, I. (1992). *Empowering Education*: Critical Teaching for Social Change. Chicago, IL: University of Chicago Press.

Spring, J. (1997) *Ozgur Egitim*, cev. A. Ekmekci, Istanbul: Ayrinti.

Tasoglu, A. K., & Bakac, M. (2010). The effects of problem based learning and traditional teaching methods on students' academic achievements, conceptual developments and cientific process skills according to their graduated high school types. *Procedia-Social and Behavioral Sciences*, *2*(2), 2409-2413.

Timmins, A. A., & Bryant, S. L. (1999, November). Quality learning teams have a motivating effect on student teachers. Hong Kong Educational Research Association (HKERA) *16th Annual Conference: Exploring New Frontiers in Education,* The Hong Kong Institute of Education, China.

Tosun, C., & Taskesenligil, Y. (2012). Probleme Dayali Ogrenme Yonteminin Ogrencilerin Kimya Dersine Karsi Motivasyonlarina ve Ogrenme Stratejilerine Etkisi. *Turk Fen Egitimi Dergisi, (TUFED), 9(1),* 104-125.

Topdemir, H.G. & Unat, Y. (2012). *Bilim Tarihi.* Pegem akademi: Ankara.

TUBITAK [Turkiye Bilimsel ve Teknolojik Arastirma Kurumu](2010). *Ortaogretim Ogrencileri Arasi Arastirma Projeleri Final Yarismasi* (29-Nisan-4 Mayis 2010). TUBITAK: Ankara.

TUBITAK [Turkiye Bilimsel ve Teknolojik Arastirma Kurumu] (2012). *43. Ortaogretim Ogrencileri Arastirma Projeleri Yarismasi ve Ortaogretim Ogrencileri Enerji Verimliligi Proje Yarismasi: Proje Yarismalari Kitapcigi.* TUBITAK: Ankara

TUBITAK (2014) *Proje Degerlendirme Kriterleri ve Puanlama*. Online: www.tubitak.gov.tr/sites/default/files/kriterler_ve_puanlama.pdf

Victor, E., & Kellough, R. D. (1997). *Science for the Elementary and Middle School* (8th ed.) New Jersey: Merrill Prentice Hall.

Williams, D., Youngflesh, A. & Bagg, B. (1997) *Enhancing Academic Understanding through Service-Learning: Listening to Students' Voices. Expanding Boundaries: Building Civic Responsibility in Higher Education*. Washington, DC: The Corporatiion for National Service.

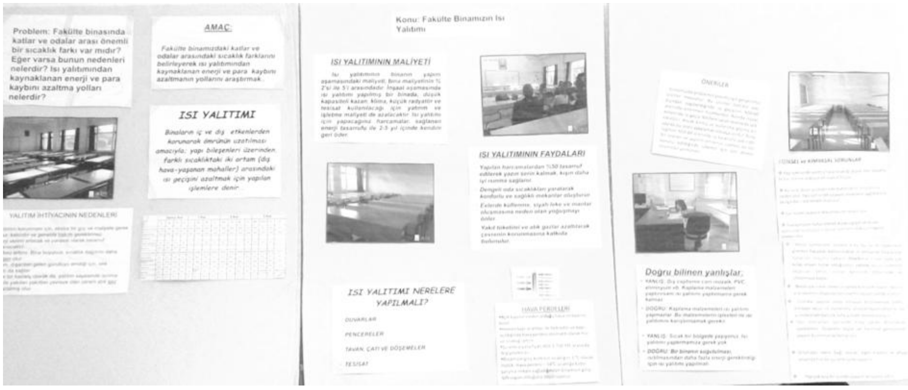
Yildirim, A. & Simsek, H. (2004). *Sosyal Bilimlerde Nitel Arastirma Yontemleri* Ankara: Seckin Yayincilik.

Yilmaz, K. & Altinkurt, Y. (2011). Ogretmen Adaylarinin Elestirel Pedagoji Ile Ilgili Gorusleri. *Ahi Evran Universitesi Egitim Fakultesi Dergisi, 12 (3), 195-213*

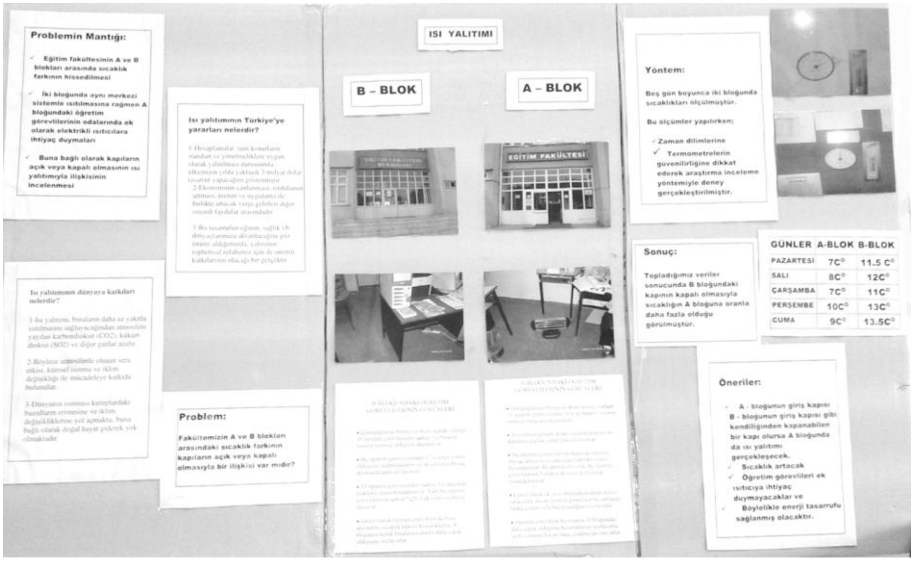
Yin, R. K. (2003). *Case study research: Design and methods*. London: Sage Publications.

Appendix

Appendix 1. First waste of heat project poster



Appendix 2. Second waste of heat project poster



Appendix 3. Data table about the first waste of heat project

	Zemin Kat				1.Kat				2.Kat				3.Kat			
	101	105	110	112	211	201	223	217	302	314	306	317	406	Kütüphane	411	421
Pencereleri Durumu	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Açık	Kapalı	Açık
Kapıların Durumu	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı	Kapalı
Petek Sayısı	4	4	4	2	2	2	4	1	2	2	3	2	2	4	2	4
Petek Uzunluğu(cm)	140	176	176	88	176	110	100	87	100	176	87	88	176	100	176	110
Kat Sayısı	Zemin	Zemin	Zemin	Zemin	1	1	1	1	2	2	2	2	3	3	3	3
Boyutu(Büyüklüğü)	680x1160	920x1200	680x1200	560x680	320x400	600x680	720x1200	280x680	560x680	360x440	680x880	600x680	360x440	920x1680	280x320	720x1200
Sınıfın Durumu	Boş	Dolu	Boş	Boş	Dolu	Boş	Boş	Dolu	Dolu	Dolu	Boş	Boş	Dolu	Boş	Dolu	Boş
Masaların Fiziksel Durumu	Fayans	Fayans	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap	Ahşap
Baktığı Yön	Kuzey	Kuzey	Güney	Güney	Kuzey	Kuzey	Güney	Güney	Kuzey	Kuzey	Güney	Güney	Kuzey	Kuzey	Güney	Güney
Sınıf /Oda	Lab.	Lab.	Sınıf	Sınıf	Oda	Toplantı Odası	Sınıf	Oda	Sınıf	Oda	Sınıf	Sınıf	Oda	Kütüphane	Oda	Bilgisayar Lab.
Derece	23 °C	21 °C	23 °C	25 °C	20 ° C	22,5 ° C	24,5 °C	22 °C	23 °C	23 °C	19 °C	23 °C	20 °C	22 °C	22 °C	22 °C

Öğretmen Adaylarının Bilim İnsanı Gibi Düşünebilme ve Davranabilme Becerileri: Eşleştirilmiş Araştırma Projesi Ödevlerinin Karşılaştırmalı İncelenmesi

Atıf:

Bulunuz, M., Tapan-Broutin, M.S., & Bulunuz, N. (2016). Pre-service teacher scientific behavior: comparative study of paired science project assignments. *Eurasian Journal of Educational Research*, 62, 195-218 http://dx.doi.org/10.14689/ejer.2016.62.12

Özet

Problem Durumu: Üniversite öğrencilerinin çoğunun gerçek yaşamdan çok boyutlu bir problemi ve sınırlılıklarını açık ve net ortaya koyarak test edilebilir şekilde tanımlama becerisine sahip olmamaları, onların problemin çözümü için güvenilir bir yöntem, sonuç ve yargıda bulunmalarına engel olmaktadır. Gerçek yaşam içinde problemler genellikle açık-uçlu, çok boyutlu ve karmaşıktır. Günümüzde geleneksel bilgi aktarımına dayalı pedagojik uygulamalar yerine, öğrencilerin eleştirel kapasitelerini geliştiren, yaşadıkları koşulları dönüştürmeyi düşündüren ve bunun için eylemde bulunmalarını sağlayan, gerçek yaşamdan seçilen ya da gerçek yaşamla bağlantısı kurulabilen her sürecin bir sonrakine yol açtığı içsel bağlılık ve tutarlılık içinde yürütülen öğretim faaliyetlerine ağırlık verilmelidir. Yapılan alan yazın taramasında eğitim kurumlarında araştırma-geliştirme ve inovasyon fikrini temel alan, proje uygulamaları üzerine yapılmış örnek olay çalışmasına rastlanmamıştır. Yapılan araştırmalar genellikle öğretmen adaylarının akademik başarı, kavramsal gelişim, kritik düşünme becerisi ve motivasyonu üzerine odaklanan istatistiksel çalışmalardan oluşmaktadır. Bu çalışma söz konusu eğitim-öğretim yaklaşımına örnek teşkil edebilecek bir uygulama örneğinin tanıtılması ve nitel olarak değerlendirilmesini içermektedir.

Araştırmanın Amacı: Bu çalışmada öğretmen adaylarına araştırma-geliştirme ve inovasyon fikri ve deneyimi yaşatan bilimsel araştırma projeleri tanıtılmıştır. Bu çalışmanın amacı öğretmen adaylarının fakülte binalarındaki ısı yalıtımını konu alan bir projenin, başka bir projeye dönüştürüldüğü iki projedeki öğretmen adaylarının yaşamış oldukları süreçleri ve projelerden elde edilen sonuçları incelemektir.

Araştırmanın Yöntemi: Araştırma Marmara Bölgesinde bir devlet üniversitesine bağlı eğitim fakültesinin 3. sınıfında öğrenim gören ve fen bilgisi öğretimi ve laboratuvar uygulamaları dersini alan fen bilgisi öğretmeni adayları ile gerçekleştirilmiştir. Bu çalışmada, öğrencilerin proje oluşturma süreçlerini incelemek, çalışılan durum içinde olay ve olguları yakından izlemek, derinlemesine betimlemek ve yorumlamak için nitel araştırma yöntemlerinden örnek olay çalışması tercih edilmiştir. Bu kapsamda örnek olay çalışması mülakat, gözlem, anket ve doküman analizi gibi yöntem ve teknikler kullanılarak fakülte binasında ısı yalıtımı konusunda birbiriyle ilişkili

yapılmış projelerin derinlemesine incelenmesinden oluşmaktadır. Fakülte binasında ısı yalıtımı konusunda yapılan iki proje ile ilgili veriler sistematik bir şekilde toplanmış ve değişkenler arasındaki ilişki tespit edilmeye çalışılmıştır. Araştırmada elde edilen veriler, araştırmacılar tarafından oluşturulan temalar kullanılarak çözümlenmiştir. Öğretmen adayları ve öğretim elemanı tarafından gerçekleştirilen ilk projedeki eksiklikler çeşitli değişkenler açısından analiz edilmiş, bu değişkenlerin geliştirilmiş projedeki ele alınma biçimleri, projelerdeki ilerleme süreçleri ve bu süreçlerin bilimsel yapı ile uygunlukları açısından incelenmiştir. Projelerin analizleri için TÜBİTAK'ın (2014) proje değerlendirme ölçütlerinden faydalanılarak şu temalar kullanılmıştır: a) problemin açık olarak ortaya konulmuş olması; b) belirtilen problem durumu ile projenin gerçekleştirebilir olması; c) projenin önemi ve gerekliliği; d) veri toplama yöntemlerinin açık ve net biçimde belirtilmiş olması; e) toplanan verilerin problem durumuna açıklık getirecek şekilde yorumlanması ve f) projenin yaygın etkisinin açıklanmış olması.

Araştırmanın Bulguları: Birinci projede öğretmen adaylarının her gün karşılaştıkları bir problemle ilgili olarak kendi başlarına test edilebilir araştırma problemi belirlemek ve çözmek için yöntem geliştirme konusunda güçlük çektikleri görülmüştür. Benzer şekilde toplanan veriler öğrenciler tarafından problem duruma açıklık getirecek şekilde analiz edilememiş ve yorumlanamamıştır. İkinci projede ise öğretmen adayları, öğretim elemanının rehberliğinde araştırma problemini ve alt problemleri daha sınanabilir bir şekilde ifade etmiş, geçerli ve güvenilir veriler toplanarak analiz edebilmişlerdir. Bu projenin başarılı olmasında iki faktör önemli rol oynamıştır. Birincisi sıfırdan araştırma problemi belirlemeye oranla daha önce yapılmış olan bir projenin problemini revize etmenin daha avantajlı olduğunu göstermektedir. Bu bulgu, bilimin döngüsel ve birikimsel ilerleyen bir süreç olduğu gerçeği ile paralellik göstermektedir. Projenin başarıya ulaşmasındaki ikinci faktör ise öğretim elemanı ve öğrenciler arasında diyalog ve işbirliğinin daha yoğun biçimde gerçekleşmiş olmasıdır. Bu bulgular eleştirel pedagojinin öğretmen ve öğrencinin diyalog ve işbirliği içinde aynı konuyu tartışma, gerçekliği deşifre etme, gerçekliğe eleştirel müdahalede bulunma, gerçekten düşünme ve gerçekliğe dayalı eylemde bulunma yaklaşımının uygulanmasına örnek teşkil etmektedir. İlk projede toplanan verileri analiz edilmediği ve sonuçlandırılamadığı için yaygın etkisi de olmamıştır. Oysaki ikinci projede açık, net ve sınanabilir bir araştırma problemi bilimsel verilere dayalı gerçekleştirilebilir bir proje ortaya konulmuştur. Böylece ikinci projenin yaygın etkisi artmış ve projeye konu olan A blok bina kapısının fakülte dekanlığı tarafından değiştirilmesi ile bu yaygın etki gözle görülür hale gelebilmiştir. Aynı zamanda bu bulgular döngüsel araştırma projesi uygulamasının, öğretmen adaylarının bilgiyi gerçek yaşam problemlerine uygulama becerisini geliştirme, karmaşık problemlerin nedenlerini anlama ve çözmek için pratik eylemde bulunma ve kritik düşünme becerisini geliştirdiğini ortaya koymaktadır.

Araştırmanın Sonuçları ve Önerileri: Bilimsel araştırma projeleri öğrencileri araştırmaya teşvik ederek onların bilim insanı gibi düşünme ve davranabilme becerilerini geliştirmelidir. Bunun için araştırma projeleri doğrusal değil, döngüsel bir süreç olarak ele alınmalıdır. Ancak bu şekilde öğrencilerin yaşadıkları bilimsel araştırma proje deneyiminin niteliği arttırılabilir. Bu şekilde öğrenciler yaptıkları araştırma projelerinden araştırma-geliştirme ve inovasyonun fikrini deneyim yaşayarak kazanabilirler. Öğretmen adaylarına proje gerçekleştirme eğitimlerinin verilmesi suretiyle ilk ve orta öğretim düzeyindeki öğrencilerine döngüsel araştırma sürecini yaşamaları ve yaşatabilmelerinin sağlanması gerektiği söylenebilir. Okullardaki öğretmenlere ise bu konudaki alan yazın zenginleştirerek projeye katılacak rehber öğretmenlere hizmet içi eğitim yoluyla örnek uygulamalar tanıtılmalıdır. Hizmet içi eğitimlerde proje bankalarına alınmış her bir projenin bilimsel araştırma döngüsüne girebilecek potansiyel içerdiği örnek uygulamalarla ortaya konulmalıdır. Bu şekilde yapılan proje uygulamalarıyla bilimsel araştırmalarda araştırma-geliştirme ve inovasyon fikrinin aşılanarak yaygınlaşması sağlanabilir.

Anahtar Sözcükler: Bilimsel araştırma, proje-temelli öğrenme, ARGE, inovasyon, öğretmen eğitimi.